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GUTS

BY RUFUS T. STROHM

The title of my verse, I fear,
May jar upon the cultured ear
And shock the squeamish and precise,
Whose speech is always over-nice;
But yet the simple truth remains
That, whether men have brawn or brains,
The thing that lifts them from their ruts
Is guts.

With purpose firm as adamant
It meets the coward's whine, "I can't,"
And in a voice emphatical
Declares the doctrine of "I shall!"
It turns the idler's "It may be"
To roseate reality,
And laughs with scorn at "ifs" and "buts,"
Does guts.

It picks the fighter from the dust
In which he falls, and cries "You must!"
Till, heartened and aroused anew,
He struggles up and battles through.
It rips the planking from the floor
And bursts the oaken prison door
That Fate or Fortune coldly shuts—
That's guts!

Largest Ice Plant in the West

By VICTOR J. AZBE
Consulting Engineer, St. Louis, Missouri

A 350-ton plant in which there has been much original development. Features are drum-type copper steam condensers, ammonia condensers made up of 8-in. pipe, an ice-making system employing 800-lb. cans, an ice-handling crane having six controls, a specially designed ice tank, flooded brine coolers using 22.6 sq.ft. of surface per ton of ice and a 15,000-ton storage house storing ice to a depth of 60 feet.

IN DENVER, Colorado, the ice plant of the Colorado Ice and Cold Storage Co. is of exceptional interest. Features that were developed in this plant are now in general use throughout the country. George L. Vail, chief engineer, has shown remarkable ingenuity during the 29 years he has had charge of the plant. Boiler room, engine room, ice tank and freezing system, ammonia condensers, steam condensers and ice storage all show characteristic individuality. It is safe to say that there was more original development in this ice plant than in any other in the United States.

The full capacity of the plant is 350 tons of ice per day, at which rate it is operated six months in the year. During the cooler six months about 210 tons of ice is manufactured per day, of which 110 tons is put in storage for summer peak loads and the rest is sold.

The Boiler Equipment

Six boilers serve the plant, the steam pressure maintained being 130 lb. gage. Two of the boilers are of the B. & W. water-tube type, each rated at 350 boiler-horsepower. These two units are connected to an economizer. Two of the boilers are of the Parker type and of 411 hp. capacity each. The operating force were favorably inclined toward these boilers, claiming that they were good steamers and efficient. An economizer was not considered essential as the boiler proper includes an economizing element. The short stack serving these two boilers made it necessary to use induced draft. During a test period, operating the boilers at rating, a flue-gas temperature of 450 deg. F. was obtained. The other two boilers in the plant are of the Kewanee type, rated at 250 hp. each.

All boilers are hand-fired, and the grates are of the Vail nozzle type, the air openings being round, one-half inch diameter on the lower side of the grate and one-quarter inch at the top. The free air opening is 12.8 per cent. of the grate area. The fuel burned is Colorado lignite having a heat value of about 10,000 B.t.u. per lb. It is of the black variety and of higher grade than the brown Texas lignite.

Boiler-feed water is obtained from an artesian well. This water is good for boiler purposes as it practically contains no scale-forming matter. The condenser circulating water is obtained from a surface well by means of two 6-in. centrifugal pumps directly connected to turbines, each having a capacity of about 2000 gal. per min. This water is at a temperature of about 54 deg. F., summer and winter. It first passes over the ammonia condensers, leaves at about 75 deg. F., and at that temperature goes to the steam condensers. The characteristic of this water is that it begins to deposit heavy scale at a temperature of about 110 deg. F., so that the steam condensers become heavily coated in a short time.

The Four Refrigerating Machines

In addition to the usual auxiliaries the engine room contains three 250-ton and one 75-ton refrigerating machines, one a cross-compound, one a simple Corliss with single-acting compressor cylinders, and two simple Corliss-driven compressors. The Corliss-engine cylinders discharge at atmospheric pressure into steam condensers. These condensers are drums 10 ft. long and 37 in. diameter made of thin-gage copper. When the plant is operated under full capacity, there are 14 of these condensers in use, and since the full plant capacity is 350 tons of ice per 24 hours, then each unit condenses steam for 25 tons of ice each 24 hours.

One advantage of these condensers is that copper is a great deal better heat conductor than iron, but their remarkable quality is their self-cleaning capacity. A demonstration for the writer's benefit proved a great surprise. From a heavily scale-coated condenser, steam was shut off but cooling water allowed to circulate. Immediately the scale began to crack and fall off and expose the clean smooth copper surface. In this way most of the scale came off, and after a few minutes the water was turned off and the steam on. This dried the surface and by tapping slightly with a wooden mallet the remaining scale fell off. The whole operation of cleaning did not require much over five minutes. Another advantage of this type of condenser is durability and eventual easy repair.

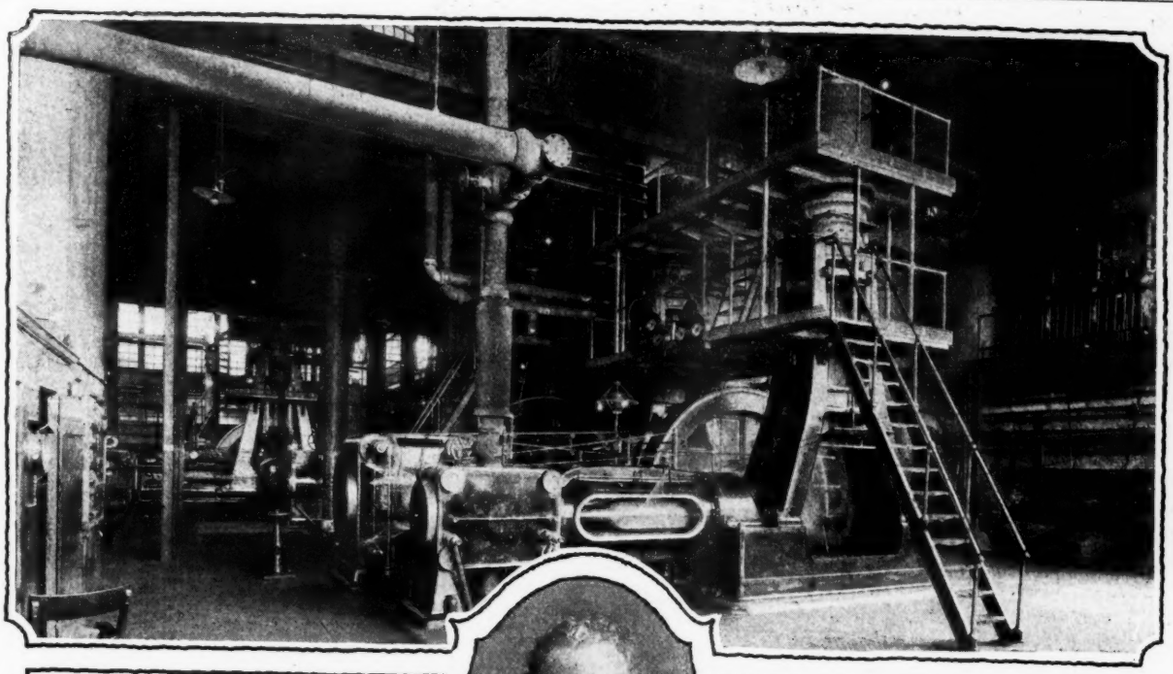
Interesting Features of the Freezing System

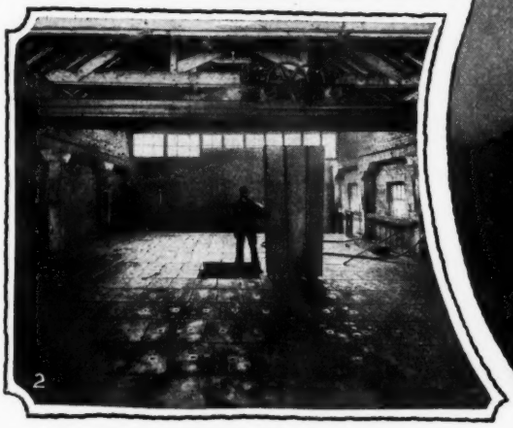
The most interesting feature of the whole plant is the freezing system. Probably this is the only plant in the country having a can system freezing 800-lb. ice blocks, and it is gratifying to report that these 800-lb.

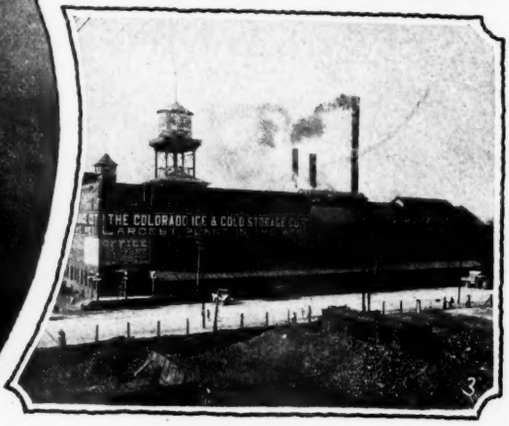
PRINCIPAL EQUIPMENT OF COLORADO ICE AND COLD-STORAGE CO. PLANT

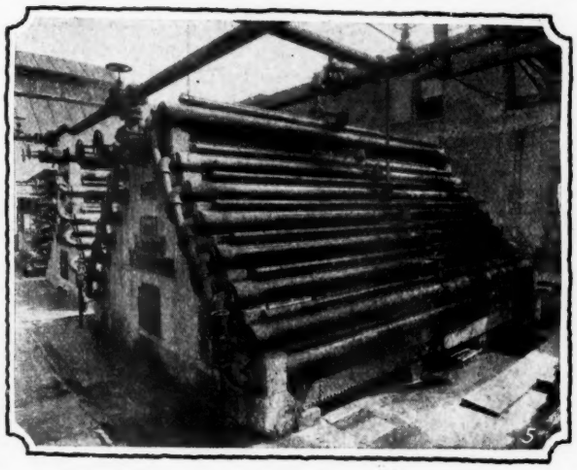
No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
1	Compressor	Vertical	22½x36½ in., 250 ton	Ice and refrigeration	Engine-driven	Frick Co.
1	Compressor	Vertical	22½x36½ in., 250 ton	Ice and refrigeration	Engine-driven	York Mfg. Co.
1	Compressor	Vertical	22½x36½ in., 250 ton	Ice and refrigeration	Engine-driven	De La Vergne Machine Co.
1	Compressor	Horizontal	15x36-in., 75 ton	Ice and refrigeration	Engine-driven	Vilter Mfg. Co.
2	Boilers	Water-tube	411-hp	Generate steam	130 lb. press.; induced draft	Parker Boiler Co.
2	Boilers	Water-tube	350-hp	Generate steam	130 lb. press.; induced draft	Babcock & Wilcox Co.
2	Boilers	Fire-tube	250-hp	Generate steam	130 lb. press.; induced draft	Kewanee Boiler Co.
1	Air compressor	Steam-driven	300 cu.ft. per min.	Air for general purposes		Ingersoll-Rand Co.
2	Pumps	Centrifugal	6-in	Condenser water	Driven by 51-hp., Kerr turbine; 2100 r.p.m.	Buffalo Steam Pump Co.
2	Pumps	Centrifugal		House supply	Driven by 23-hp. Kerr turbines; 1550 r.p.m.	Buffalo Steam Pump Co.
2	Pumps	Centrifugal		Boiler feed	Driven by Kerr turbines	Buffalo Steam Pump Co.
6	Pumps	Centrifugal		Water and brine	Driven by 23-hp. Kerr turbines; 1550 r.p.m.	Buffalo Steam Pump Co.
1	Coal unloader	Automatic	40 tons per hr.	Unload cars		Sterns-Rogers

Two 220-ton Vail double-can freezing systems, 800-lb. cans, six-control electric cranes; one 130-ton tank, Frick system; one 250-ton Vail type ammonia condenser one 250-ton Frick atmospheric condenser; one 250-ton De La Vergne atmospheric condenser; York flooded brine coolers.









FIGS. 1 TO 6. SOME VIEWS OF THE LARGEST ICE PLANT IN THE WEST. PORTRAIT OF THE CHIEF ENGINEER

Fig. 1—A view in the compressor room. Fig. 2—Ice tank with 800-lb. cans and six-control crane lifting three cans at a time. Fig. 3—Large ice plant of the Colorado Ice and Cold Storage Co. Fig. 4—Vail steam condensers of drum type. Fig. 5—Vail ammonia condenser made up of 8-in. pipe. Fig. 6—George L. Vail, chief engineer

blocks are frozen and handled with absolute success. The dimensions of the can proper are 23½ x 12½ in. at the top; 22½ x 12 in. at the bottom and 7 ft. 11 in. long. As far as effort of pulling is concerned, there is less of it here than is usually encountered with the usual system employing cans of half the size. This is primarily due to the electric crane that is employed. This crane has six controls, one for raising, one for lowering, and the others for moving lengthwise of the tank or sidewise in either direction. No pushing or guiding is required. While thawing there is no other effort required but controlling the crane. The thawing tank is located considerably below the ice tank with one side sloped so that while the cans are pulled out of the warm-water bath, they naturally take the horizontal position required for dumping.

The crane is arranged to pull three blocks, or 2400 lb. at a time. The pulling is rapid and one workman in one hour will pull from 40 to 48 blocks. As the man is getting $3.50 per day, the cost of pulling per ton of ice is between two and three cents, compared with the usual figure of 15c. per ton. Since the plant produces about 100,000 tons of ice per year, the saving by the improved system of pulling 800-lb. cans amounts to $12,000 each year.

In the Vail ice tanks there are no ammonia coils. The tank has a double bottom and is fitted with compartments. After a can is inserted into its compartment, there is an inch space between the can and the compartment wall. Brine passes from a brine cooler into the double bottom, through a ⅜-in. hole into each can compartment and up through the 1-in. space around the can. The brine level in the tank is maintained exactly at the level of the ice block when frozen. The brine overflows into a compartment, then to a tank, pump and brine cooler.

For a 50-ton system the tank occupies a space measuring in plan 27½ x 33 ft. This is remarkable concentration and is of value where real estate is expensive.

Brine is cooled in flooded coolers having 22.6 sq.ft. of surface for each ton of ice, as compared to the usual 100 to 200 sq.ft. employed. The brine cooler for the 50-ton ice tank has 160 tubes 2½ in. in diameter and 12 ft. long. The brine makes eight passages through the cooler, which occupies a horizontal position and is at all times two-thirds filled with liquid. That this liquid does not go over to the machines is proved by the fact that the discharge pressure is always at about 220 deg. F. with a condenser pressure of 150 pounds.

Through the brine cooler and the ice tank circulation of brine is maintained by turbine-driven centrifugal pumps operating against a head of about six pounds. The amount of brine circulated per minute per ton of ice is about fifteen gallons, and the temperature difference of brine entering and leaving the brine cooler is from 1½ to 2 deg. On the evaporating side of the refrigerating system the suction pressure maintained is 18 lb., but greater pressure can be obtained easily with more cooling surface.

The ammonia-condensing system consists of 29 stands of drip condensers, all being 24 pipes high and 20 ft. long. In addition the plant is equipped with condensers of Mr. Vail's own design made up of 8-in. standard pipes and arranged as shown in Fig. 5. Ammonia vapor flows successively through 14 lengths of 8-in. pipe each having 18 ft. of effective length. The 8-in. pipes are interconnected by 2-in. pipes. While the velocity in this condenser is relatively low, good results are obtained from it.

Another interesting feature is the ice storage. There are two ice-storage houses, one of 4000 tons capacity and the other, 15,000 tons. The latter probably is the largest ice-storage house in the country. When the writer visited this plant, the large ice-storage house was filled completely and ice was stacked to within two feet of the ceiling coils. Its dimensions are 175 ft. long, 60 ft. wide and 60 ft. high, which would mean that there were 30 layers and 500 tons of ice to the layer. Ice was stacked regularly and all the blocks pitched toward the center of the storage, due to pitching of the floor six inches so as to prevent any danger of the ice sliding toward the walls. The ice blocks lie directly on the floor and at the walls come close to the brine coils but do not quite touch them. The coils themselves are six inches from the wall and provide for ample air circulation.

In the large storage house there is ten miles of 1¼-in. brine piping to maintain a temperature of 16 deg. This temperature is lower than is usually considered necessary, but the result is that the ice taken out in summer is first-class and there never is any loss.

At first, objections were offered to building an ice-storage house of the height previously given. It was thought that the lower layers would not sustain the tremendous weight, but Mr. Vail proceeded systematically, testing out all objections and putting them aside. He took an ice block to a near-by machine shop and inserted it into a hydraulic press to see at what pressure it would begin to crack. The result indicated that there need be no fear on this score. Such large storage space enables the company to store cheap winter ice with a minimum of labor, and when the ice is marketed it is more desired by the trade than the ice directly from the tanks.

The Semi-Diesel Engine

By H. F. SHEPHERD

The semi-Diesel engine, hot-bulb engine, surface-combustion engine or like engine of fanciful name—what are its characteristics of construction and operation and what is its economic position? These questions are answered in the article.

COMPLETE theory of the semi-Diesel engine is still largely unwritten. At present the constructions are legion, varying not so much in mechanical details that may not be important, but rather in approach to the ideal of working involved in the stereotyped catalog or textbook description. Out of this variation arises much sales talk, and truly the purchaser without previous experience is confounded by superlatives. In what follows an attempt will be made to deal sanely with the most important variations in design and characteristics of operation from the viewpoint of the designer, also with the commercial relation between the true Diesel and the semi-Diesel.

The latter term is rather loosely descriptive of a type of engine in which vaporization of fuel (at least in some degree) and ignition are provided for by spraying the fuel charge toward a hot surface large enough to intercept all the fuel that traverses the combustion space and hot enough to produce ignition of the fuel in conjunction with the compression. The compression is lower than that employed in Diesel engines, varying actually from 150 lb. to 250 lb. per sq.in. for two-stroke-cycle types and from 180 to 300 lb. per sq.in. for four-stroke-cycle types. The injection of the fuel charge, either with or without compressed air to assist the atomization, takes place just long enough before the firing center to allow vaporization prior to ignition at that point. Solid injection of fuel or mechanical spraying is almost universal.

Economic Merit of The Type

The ever-increasing manufacture of this type is possibly sufficient evidence of its economic merit; however, the purchaser may wish to make his own analysis. This hinges on low first cost and low attendance cost. Assuming that like percentages of the initial cost may be applied to both the true Diesel and the semi-Diesel types for depreciation, upkeep, interest, insurance, etc., and dividing these fixed charges by the yearly output in horsepower-hours, the difference may be balanced against the excess fuel cost incident to operating the semi-Diesel. It is sacrcely wise to generalize on this point, as it is a local condition usually.

From the operating viewpoint, the semi-Diesel is simpler by reason of the omission of the high-pressure compressor and the gear necessary to operate the injectors and by the extreme simplicity of its injector or spray nozzle. In the plant of moderate size, where the yearly wage required to retain a man of skill and judgment may exceed the yearly fuel bill, a degree of simplicity of construction to meet the ability of the untrained operator is essential.

The semi-Diesel engine with mechanical fuel spraying exhibits one peculiarity that is not common to internal-combustion engines generally; that is, its operation is seriously influenced by its hot-surface temperature and in a lesser degree by its air-charge temperature at the time of injecting the fuel. This calls for compromise in its design and certain measures for compensation in order that it may operate satisfactorily at all loads.

A cold-air charge or a cold vaporizer at light loads will result in poor vaporization and possibly irregular ignition and the discharge of liquid fuel at the exhaust. The reader may be able to grasp this the better with the knowledge that it is a good fuel oil indeed that will yield 60 to 70 per cent. of distillate when heated to 360 deg. C. The Southwestern crudes, and especially their residuums which are sold as fuel oil, and the California fuel oils seldom yield more than 40 to 50 per cent. at that temperature. This alone would not be a difficult condition to meet, but at the other extreme the entering fuel must not meet too high a temperature.

The heavier petroleum fuels are subject to what is technically called "cracking" when exposed to high temperatures. This is essentially a rearrangement or alteration of the combinations of hydrogen and carbon which compose the fuel. The general result is the production of lighter oils (or their vapors), gas and free carbon. Controlled, this action is the basis of the Rittman process and the older Burton process for the production of larger quantities of light fuel than can be extracted from heavier petroleums by simple distillation.

Proper Control of Temperature

Repeating, the entering fuel must be subjected to a temperature no higher than necessary to vaporize it just before ignition. Some cracking will take place but it must be limited by proper control of temperature so that the least possible amount of uncombined carbon will be set free in mass form. This is not true of the Diesel engine with its air-blast injection. The reason is very simple. Oil introduced on a high-pressure air blast is so finely subdivided and distributed that each oil molecule may readily meet its oxygen and be instantly consumed. Oil introduced by a mechanical spray is delivered in microscopic drops even when sprayed at one or two thousand pounds per square inch. So-called high-pressure mechanical sprays work at from 5000 to 7000 and even 10,000 lb. per sq.in. They are not in extensive commercial use here, being too difficult to maintain, although such systems obviate serious need of careful temperature control by reason of their more perfect atomization.

If combustion begins at once on the surface of the globules of the normal moderate-pressure spray, their inner content will be "cracked," setting carbon free relatively in mass, which in this form will not burn completely in the time allowed by a single combustion period. Further, even if this does not account for all the inefficient combustion under excessive temperatures, even though each "drop" flashes into a little body of vapor if combustion begins before proper intermixing or diffusion of each small "cloud" through the air provided for its combustion, the burning on the surface will isolate the body of fuel vapor from its air with resulting escape of unburned or partly burned fuel.

The same reasoning applies to that part of the fuel that actually reaches the vaporizing surface. Vaporization and diffusion must, as far as possible, precede ignition and this necessitates temperature control between what are fortunately wide limits, but none the less limits. A red-hot vaporizer is fatal to combustion, the upper limit in modern designs being about 450 to 475 deg. C., or just below a red heat in the dark. Of course the term diffusion is not used in the scientific sense. Owing to the well-known "stormy" state of the air charge enduring after its introduction at high velocity, this action is very rapid.

The Semi-Diesel an Explosion Engine

The semi-Diesel engine is essentially an explosion or Otto-cycle engine. Thorough preparation for instant ignition and rapid propagation is essential to the nearest possible or practical approach to this ideal. Technically, this is a more perverse problem than anything involved in the practical cycle of a Diesel engine. Practically, it is a successful alternative because its functioning devolves upon stationary or at least low-pressure elements of design that may be put into the hands of almost any class of labor.

Light-load operation with an engine of moderate compression and moderate spray pressure is made possible by deliberate retention of some of the exhaust gases; that is, the scavenging is purposely made more or less inefficient. This is accomplished in the case of the four-stroke-cycle types by the valve setting. Both exhaust and inlet are held open simultaneously for as much as 50 deg. on the suction stroke, permitting enough hot gas to be reaspirated to warm the air charge. The same result is accomplished with two-stroke-cycle designs by manipulating port dimensions and scavenging pressures and volumes. These measures, of course, reduce the available maximum mean-effective pressure, but there is little choice in the matter. The alternative is to use a high compression and a very high spray pressure, in which event the homely virtues of the semi-Diesel type are sacrificed to an ideal more satisfactorily realized in the Diesel type itself.

Throttles on the Air Inlet

A compromise is sometimes effected by fitting a throttle on the air inlet for use at light loads, thus permitting more complete scavenging for full-load operation and therefore greater capacity. It would seem that this might serve as the sole means of compensation; however, experience has shown that regulation of the air-charge temperature alone is not sufficient. There must be some direct or independent means of cooling the hot surface under heavy loads as well.

The oldest method of regulating these temperatures is the injection of water into the power cylinder with the introduction of the air charge, the quantity of water fed increasing with the load either automatically by means of a governor-controlled pump or valve or by simple manual adjustment. The former is, of course, necessary for rapidly fluctuating loads. More recently, the hot ball or vaporizer has been fitted with an annular jacket through which a sufficient quantity of water is fed to maintain it at the proper temperature. This arrangement is not automatic as built to date.

Another device is a hot ball or vaporizer in the form of a drawn-steel pot let down into the combustion chamber. The fuel is sprayed against its bottom. A jacketed cover secures the pot in place and closes the interior from the atmosphere. This pot carries a charge of mercury boiling at 360 deg. C. An excess of heat is automatically dissipated by the boiling of the mercury at a consistent rate and the condensation of the vapor against the jacketed cover above, the cool liquid falling back into the boiling liquid below.

The design of the combustion chamber has but one theoretical requirement. As much of the air as possible should be massed between the fuel injection and the vaporizer at firing time. Air isolated in clearances and pockets cannot lend its oxygen to the burning of the fuel.

In this country and abroad two-stroke-cycle semi-Diesel designs predominate. The higher cyclical temperature of the two-stroke-cycle engine for a given compression lends itself nicely to the requirements of the type, especially to light-load operation.

Designs With Crossheads and Without Equally Divided

The trade is about equally divided between designs with crossheads and those without. In the case of the two-stroke-cycle engine, the situation is essentially this: Air for scavenging is usually pumped by the displacement of the crank end of the piston. If a crosshead is employed, the crank end of the cylinder may be closed off by a bulkhead in the bed and a stuffing-box. If it is not used, the space within the crank box is utilized as the scavenging-air chamber and the main bearings must be packed air-tight.

The method of accomplishing this should always be investigated. The original way was to use simple non-adjustable bushings for the main bearings, depending on their fit and lubrication for air-tightness. After slight wear, aside from the play, when air leakage develops, the oil is blown out and the lubrication is seriously hindered. Somewhat later designs use soft packing in a stuffing-box at the outside of the main journals, and possibly the best is one adapted from European practice in which snug collars are fitted to the crankshaft close up to the throws and pressed outward by springs so as to seat against shoulders in the bearing housing or bedplate. These collars are splined to the shaft or slide on pins extending from a shoulder next the web and revolve with the shaft. Seat wear is, of course, taken up laterally by the springs. This gives the designer practically a free hand in the structure of the main bearings in the case of the single-cylinder engine. Multicylinder engines with crank-case compression present a more difficult problem in the design of the center bearings. When a crosshead is employed, main-bearing design involves no other problem than a convenient and secure adjustment and the application of any chosen means of lubrication. Among these latter, splash lubrication is made possible. This may not be the most modern and elegant means of lubrication, but it is at least intensely practical under adverse conditions. Its use is not possible with crank-case compression, as the oil would pass away through the scavenging ports.

No form of fuel spray or injector may be described as the best, as what is right with one form of governing system, fuel pump or combustion chamber or even development may be entirely unsuited to another. The most essential feature is that it shall cease delivery, or cut off, without dribble or spurt immediately on completion of the pump movement. This may be shown by operating the engine pump quickly by hand. A poorly designed injection system or one in bad repair may

deliver almost a continuous stream of fuel instead of an intermittent, well-timed spray, despite what may be reasonably expected from the known mechanical movement of the pump.

All oil engines should be fitted with relief valves, preferably of the spring-loaded type. A cold start, leaving unconsumed oil in the combustion chamber or derangement of the spray nozzle may produce powerful premature explosions that have been known to wring the hubs from the flywheel spokes or to sunder the engine structure in some uncanny fashion when such valves are not provided.

Heine Marine Cross-Drum Boiler

The latest design of marine boiler built by the Heine Safety Boiler Co., St. Louis, Mo., is of the cross-drum type. The boiler proper consists essentially of two flat steel rectangular box headers and a cylindrical steam drum. The main bank of 3½-in. tubes connects the two box headers, and when the boiler is set in its operating position, they are inclined at an angle of 16 deg. to the horizontal.

Above the front box header and slightly to the rear of it is placed the steam drum, which is connected to the front header by a row of nearly vertical short tubes, or nipples, and to the rear header by a row of longer tubes, which are horizontal when the boiler is set. The boiler is supported by a steel structure resting on and secured to proper foundations in the vessel.

The steam drum varies in the several sizes of boilers from 36 in. to 48 in. in diameter. It consists of a single plate steel shell of a thickness corresponding to the pressure requirements and has a double-riveted, double-butt-strapped longitudinal-riveted seam and flanged and dished steel heads, one of which has a manhole. Where the tubes enter and are secured to the shell of the drum, reinforcing plates are fitted.

Inside the drum is a steel deflection plate of sufficient length to cover the ends of the horizontal tubes and extending below the water level, its purpose being to act as a separator for the mixture of steam and water entering the drum through the horizontal tubes. The water thrown violently against this plate runs downward into the body of water below, and the steam passes along and around the ends of the plate and to the dry pipe above.

A scum pan of the usual "dish" type, with its cover plate slightly raised to produce an efficient "skimmer" effect, is located at the center of the drum exactly on the water line and piped to a surface blow outlet on the front of the drum shell.

Surge plates are fitted to check the rush of water along the drum as the vessel rolls in a seaway.

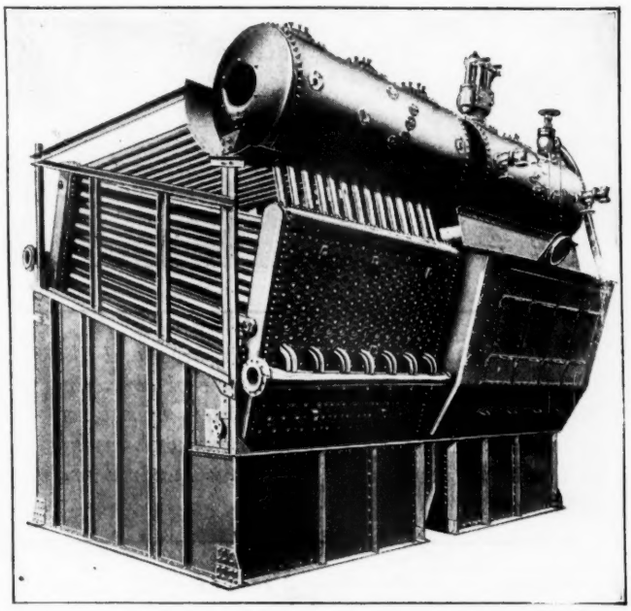
The main steam outlet is provided with a dry pipe of ample area. It is placed as near the top of the drum as practicable and has slots cut through its upper side, the area through these slots exceeding that of the outlet opening.

Zinc slabs are also fitted in the steam drum conforming to the navy standard of three-quarters of a square foot of exposed zinc plate for each 100 sq.ft. of heating surface. A pressed-steel basket catches the disintegrated zinc.

The box headers are so constructed that all seams are readily accessible for inspection and recalking without tearing away the boiler casing.

The two flat surfaces of the box headers are stayed with large hollow steel stay-bolts screwed through tapped holes in the plates and with their projecting ends riveted over on the outside. The holes through the stay-bolts are of ample size to pass freely a ⅜-in. pipe lance for soot blowing.

Superheaters of the waste-heat type for low or medium superheat are placed in the base of the uptake, as near as possible to the exit of the gases from the boiler. For higher superheat the elements are placed where they will be in contact with gases of higher temperature and are often fitted just below the middle baffle, the superheater elements passing through the 5-in. stay-tubes between the headers located outside the boiler. The right-angle bend of the superheater tubes entering the top of the front pipe header is arranged at one end of the boiler only and permits of the tubes being more easily removed and replaced than if they were straight throughout.



NEW MARINE CROSS-DRUM BOILER

The boilers are built in accordance with the rules and regulations of the United States Board of Supervising Inspectors and are approved by Lloyd's Register of Shipping and the American Bureau of Shipping.

The casing about the furnace proper is lined with refractory walls 12 in. thick, and above the lower baffle the lining is 7½ in. thick.

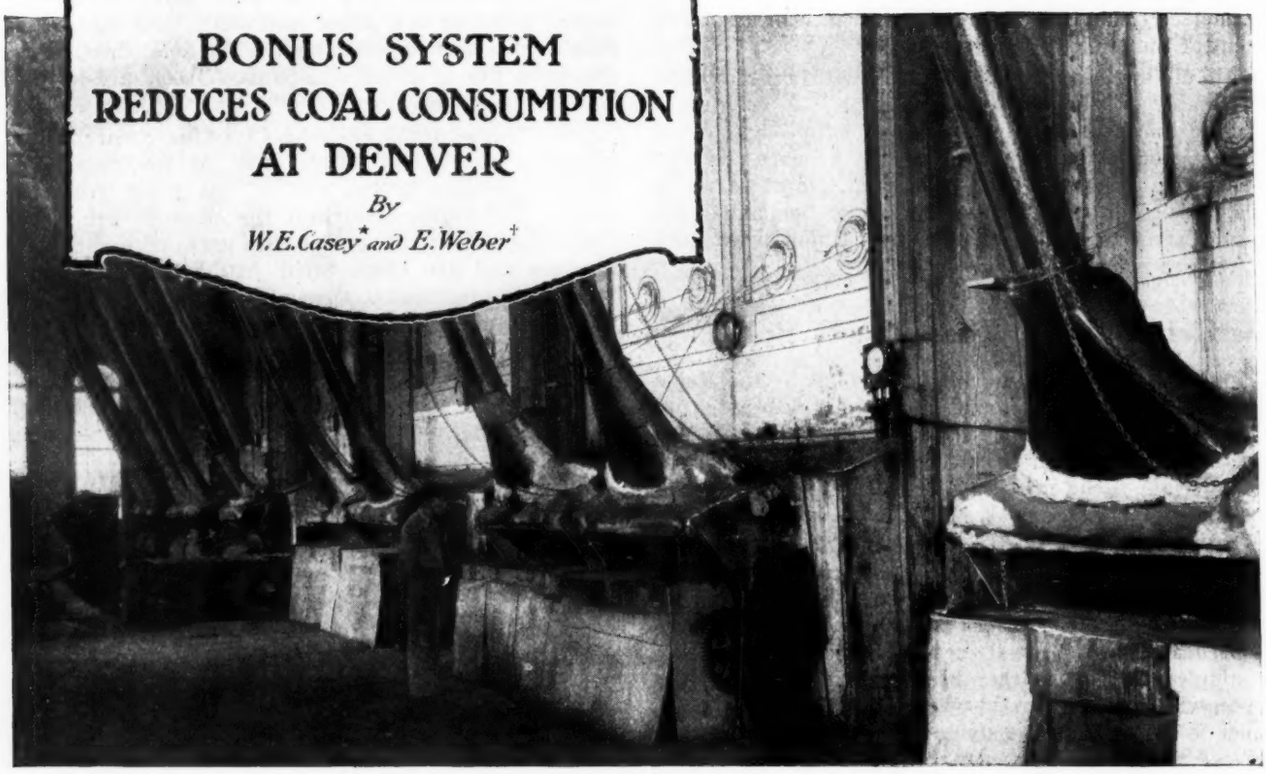
The furnace fronts for coal burning are fitted with balanced in-swinging doors above and below the grate.

The circulation is downward in the front box header and upward in the rear box header, upward and back in in the lower majority of the bank of inclined tubes and downward and to the front in a few upper rows of inclined tubes; the steam parting from the water in the upper portion of the rear header and passing into the steam drum through the horizontal tubes as before described.

Should oil or impurities enter with the feed, the scum formed may be removed by operating the surface blow with the water level at the middle of the glass. Sediment will be thrown down in the front header, where the bottom blow is arranged to remove it.

BONUS SYSTEM REDUCES COAL CONSUMPTION AT DENVER

By
W. E. Casey* and E. Weber†



By the installation of a new turbine and the introduction of the bonus system, coal consumption on the Denver Tramway system is reduced to less than 2.5 lb. per kilowatt-hour with saving in operating expenses of about one hundred and fifty thousand dollars per year.

IN THESE days of increased cost of production and operation, it will be of interest to learn how the Denver Tramway has succeeded in improving its power plant and, in spite of the increased cost of labor and coal, has, by greatly reducing the coal consumption per kilowatt-hour, kept the burden from rising to an intolerable extent.

Shortly after F. W. Hild was appointed general manager of this company, he called in E. A. West, then efficiency engineer of the Portland Railway, Light and Power Co. and now chief engineer of the Denver Tramway, to make an investigation and report on the power situation that confronted the company. This report showed that it would be best to install a turbine of capacity sufficient to carry the maximum load of the system and in this way to obtain a better average water rate than was possible with a number of small units.

To explain more in detail the improvements that were made in the plant, it will be necessary to enumerate the apparatus formerly at the power house. At the end of the year 1915 the principal equipment consisted of: Thirteen 415-hp. and six 705-hp. Stirling boilers, all equipped with chain grates, superheaters and economizers; three 800-kw. direct-current cross-compound, engine-driven generators, one 1600-kw. direct-current, cross-compound engine-driven generator, one 1500-kw. alternating-current, cross-compound engine-driven generator, and two 2000-kw. alternating-current turbo-generators. One of the 800-kw. generators had to be "scrapped" in August, 1916.

*Superintendent of power, the Denver (Colo.) Tramway.
†Mechanical engineer, the Denver (Colo.) Tramway.

New 7500-Kw. Turbine and 300-Kw. Rotary Converter Installed

The new equipment, construction work for the installation of which was begun about August, 1916, included one 7500-kw. turbine, hereafter referred to as No. 8 turbine, with surface condenser, and one 300-kw. rotary converter. The turbine is shown in Fig. 1. Owing to delays in delivery, the rotary was not placed in service until March, 1917, and the turbine not until August, 1917, but during the time of construction, or rather after the fall of 1915, the power-house performance was watched closely. Suggestions made by employees were considered carefully and many were adopted. At the same time the employees received advice and instruction so as to enable them better to understand their duties.

It was recognized that to obtain the full benefit of the equipment, both old and new, a method would have to be found that would give the men some special interest in their work, and after making a careful study of the subject, a proposed bonus system was drawn up. In July and August, 1917, the power-house employees were given an opportunity to make comments on the proposed bonus scale, and with some minor changes the order was put in effect Sept. 1, 1917, in the form following:

Bonus System for Power-House Employees[1]

1. Each employee on the power-house payroll shall be entitled to a bonus, depending on the coal consumption per kilowatt-hour. The method of calculating this bonus will be explained in detail in the following paragraphs:

2. The coal used during each month shall be figured from the mine weights. The amounts of coal on hand in bins shall be estimated by the superintendent of power at the end of each month.

3. The kilowatt-hour output for the month shall be the entire amount generated for the month and shall include station power and light. The amount used for station power and light shall not exceed 2.5 per cent. of the total amount generated if No. 8 turbine is in service, and shall not exceed 4 per cent. if No. 8 is in repair. Each 5000 kw.-hr., or fraction in excess of this amount, shall be figured to increase the coal consumption by 0.01 lb. per kilowatt-hour.

4. Steam used for purposes other than power-house operation shall be credited to coal consumption; 5 lb. of steam used shall be estimated to be equal to 1 lb. of coal, or if such steam is paid for in a lump sum, then each dollar shall be considered equivalent to 1000 lb. of coal.

5. The bonus system is based on the present load characteristic and load factor; if either one or both shall change materially, it will constitute a cause for a revision of the bonus scale.

6. If the coal consumption in succeeding months varies more than 0.1 lb. of coal per kilowatt-hour, the chief engineer of the company shall make an investigation before a bonus is paid.

7. The bonus scale is based on lignite coal from the Leyden mine with a heat value of 9500 B.t.u. per lb. If other coal is used, the theoretical amount of coal used shall be figured to be in proportion to the heating value of the coal determined by a responsible chemist.

8. The amount of bonus each employee shall receive will be calculated by dividing the total bonus by the number of men on the power-house payroll. In determining the number of men on the power-house payroll, the following rules shall govern:

a. Extra men taking the place of employees on the sick list shall not be figured as an addition to the number of power-house employees unless on the power-house payroll for a full month or longer. Employees on the sick list for six days or longer shall not be entitled to a bonus, but shall be included in the number of power-house employees as long as they remain on the power-house payroll.

b. Employees taking their vacation shall be included in the number of employees on the payroll and shall receive their bonus, but in case that it is necessary to employ extra men to take the places of men absent on vacation, the total amount of wages paid such extra men shall be deducted from the total amount considered in calculating the bonuses. These extra men shall be entitled to a bonus if they are on the power-house payroll for a full month or longer; but shall otherwise be considered as extra men as outlined above.

9. If No. 8 turbine has to be taken out of service for repairs and the operating force is not at fault, the bonus shall be calculated in the following manner: The output of the old equipment shall be taken at 4 lb. of coal per kilowatt-hour and the corresponding amount of coal deducted from the total monthly consumption. The resulting quantity of coal divided by the kilowatt-hour output of No. 8 turbine shall be used to determine the bonus.

10. If No. 8 turbine has to be taken out of service for repairs due to faulty operation, the whole engine-room crew shall not be entitled to a bonus. In this case each fraction of a month needed to repair No. 8 shall be considered as a full month.

11. No power-house employee shall be entitled to a bonus if, through his fault, damage is caused to the power house or any of its equipment, and if inspection has been overlooked by the foreman to whom this employee reports, he also shall not be entitled to a bonus.

12. In case of power interruption, due to faulty operation, the bonus will be figured for the total number of power-house employees, but the particular employees at fault shall not be entitled to any bonus.

13. Payment of the bonus shall be made in the following manner: 90 per cent. of the total bonus earned will be paid out as outlined above, 10 per cent. will be retained, and this sum paid out semiannually to all men who have been on the power-house payroll for the half year or longer just preceding.

14. The following bonus scale shall be used to determine the proper amounts:

Coal per Kw.-Hr., Lb.	Total Bonus per Month	Coal per Kw.-Hr., Lb.	Total Bonus per Month
3.11 to 3.09	$2	2.75 to 2.73	344
3.09 to 3.07	4	2.73 to 2.71	382
3.07 to 3.05	8	2.71 to 2.69	422
3.05 to 3.03	14	2.69 to 2.67	464
3.03 to 3.01	22	2.67 to 2.65	508
3.01 to 2.99	32	2.65 to 2.63	554
2.99 to 2.97	44	2.63 to 2.61	602
2.97 to 2.95	58	2.61 to 2.59	652
2.95 to 2.93	74	2.59 to 2.57	704
2.93 to 2.91	92	2.57 to 2.55	758
2.91 to 2.89	112	2.55 to 2.53	814
2.89 to 2.87	134	2.53 to 2.51	872
2.87 to 2.85	158	2.51 to 2.49	932
2.85 to 2.83	184	2.49 to 2.47	994
2.83 to 2.81	212	2.47 to 2.45	1058
2.81 to 2.79	242	2.45 to 2.43	1124
2.79 to 2.77	274	2.43 to 2.41	1192
2.77 to 2.75	308	2.41 to 2.39	1262

15. If any employee of the power house should find the bonus, as figured by the auditor, not to be correct, they can appeal to the chief engineer of the company, whose decision shall be final.

[1]Copy of Denver Tramway Standing Order. No. P. 5.

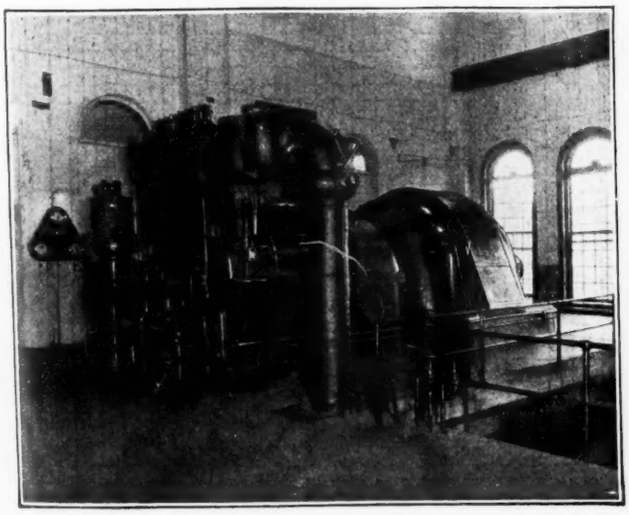


FIG. 1. NEW TURBINE AT DENVER TRAMWAY PLANT

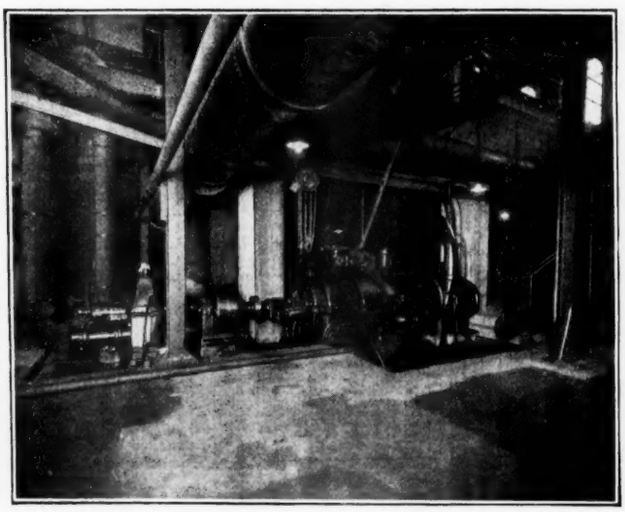
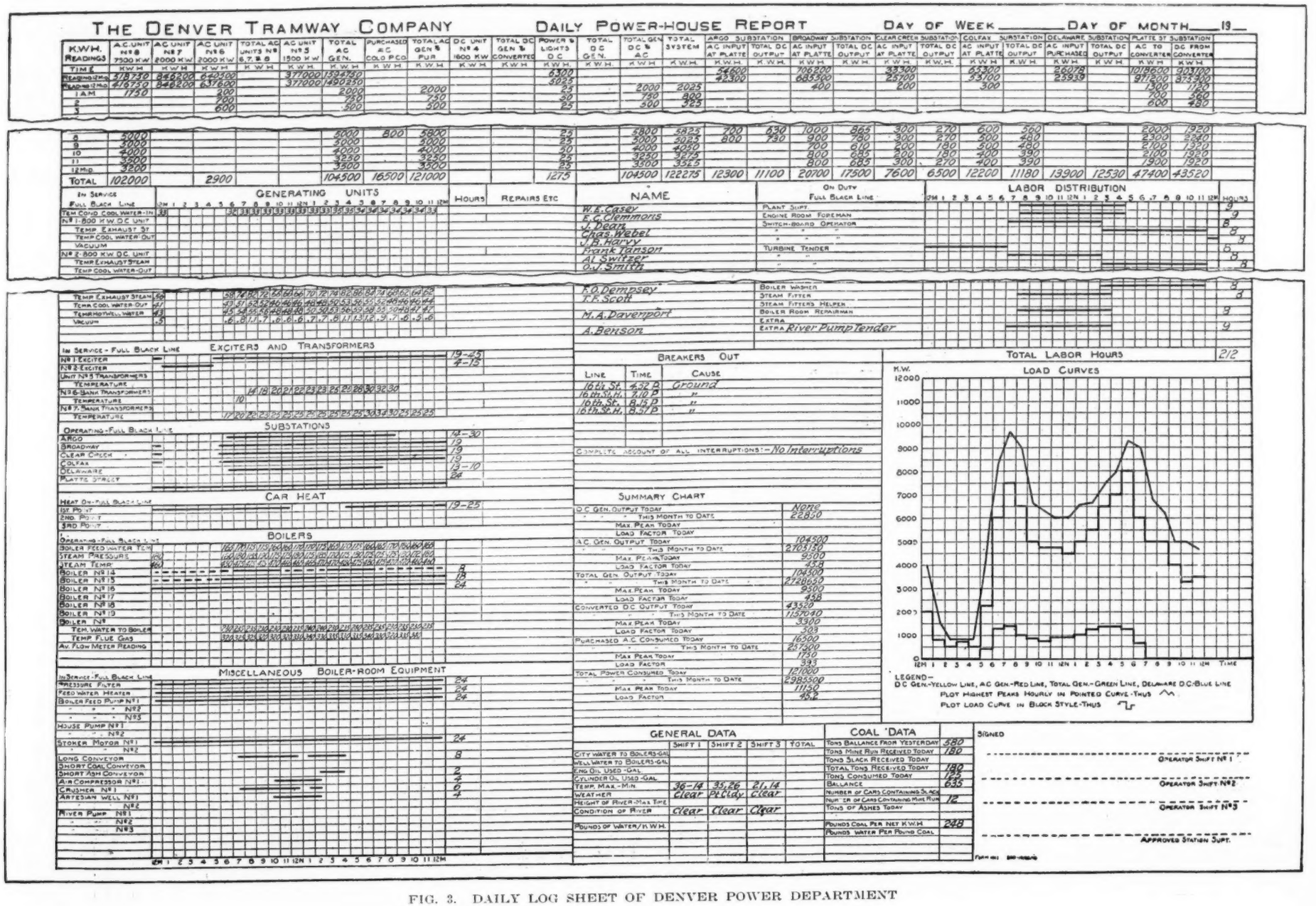


FIG. 2. AUXILIARY ROOM, BASEMENT



THE DENVER TRAMWAY COMPANY — DAILY POWER-HOUSE REPORT — DAY OF WEEK _____ DAY OF MONTH ____ 19__

K.W.H. READINGS	A.C. UNIT No 8 7500 K.W.	A.C. UNIT No 7 2000 K.W.	A.C. UNIT No 6 2000 K.W.	TOTAL A.C. UNITS No 6, 7, & 8	A.C. UNIT No 5 1500 K.W.	TOTAL A.C. GEN.	PURCHASED A.C. COLO P.CO.	TOTAL A.C. GEN & PUR	D.C. UNIT No 4 1800 K.W.	TOTAL D.C. GEN & CONVERTED	POWER & LIGHTS D.C.	TOTAL D.C. GEN.	TOTAL GEN D.C. & A.C.	TOTAL SYSTEM	ARGO SUBSTATION AC INPUT AT PLATTE	ARGO SUBSTATION TOTAL DC OUTPUT	BROADWAY SUBSTATION AC INPUT AT PLATTE	BROADWAY SUBSTATION TOTAL DC OUTPUT	CLEAR CREEK SUBSTATION AC INPUT AT PLATTE	CLEAR CREEK SUBSTATION TOTAL DC OUTPUT	COLFAX SUBSTATION AC INPUT AT PLATTE	COLFAX SUBSTATION TOTAL DC OUTPUT	DELAWARE SUBSTATION AC INPUT PURCHASED	DELAWARE SUBSTATION TOTAL DC OUTPUT	PLATTE ST SUBSTATION AC TO CONVERTER	PLATTE ST SUBSTATION DC FROM CONVERTER	
TIME	K.W.H.	K.W.H.	K.W.H.	K.W.H.	K.W.H.	K.W.H.	K.W.H.	K.W.H.	K.W.H.	K.W.H.	K.W.H.	K.W.H.	K.W.H.	K.W.H.	K.W.H.	K.W.H.	K.W.H.	K.W.H.	K.W.H.	K.W.H.	K.W.H.	K.W.H.	K.W.H.	K.W.H.	K.W.H.	K.W.H.	
Reading 12 MID	518730	842200	640300		371000	1532430					6300				34600		706200				93300		26078		1078200	903700	
Reading 12 MID	416750	842200	637600		371000	1450350					3025				42300		683500		25700		93100		25939		971200	873300	
1 AM	1750		200			2000		2000			25		2000	2025			400		200		300				1300	1120	
2			700			750		750			30		750	800											700	560	
3			600			500		500			25		500	525											600	480	
4																											
5																											
6	5000					5000	800	5800			25		5800	5825	700	630	1000	865	300	270	600	560			2000	1920	
7	3000					3000		3000			25		3000	3025	800	730	900	780	300	270	500	480			2300	2220	
8	4000					4000		4000			50		4000	4050			700	610	200	180	500	480			2100	1920	
9	3250					3250		3250			25		3250	3275			800	685	200	180	400	390			2100	1920	
10	3500					3500		3500			25		3500	3525			800	685	300	270	400	390			1900	1920	
11	3200																										
12 MID																											
TOTAL	102000		2900			104500	16500	121000			1275		104500	122275	12300	11100	20700	17500	7600	6500	12200	11180	13900	12530	47400	43520	

GENERATING UNITS (In Service — Full Black Line; 12M 1 2 3 4 5 6 7 8 9 10 11 12N 1 2 3 4 5 6 7 8 9 10 11 12M)

	Hours	Repairs Etc
Tem Cond Cool Water-In	33	
No 1-800 K.W. D.C. Unit		
Temp Exhaust St		
Temp Cool Water-Out		
Vacuum		
No 2-800 K.W. D.C. Unit		
Temp Exhaust Steam		
Temp Cool Water-Out		
Temp Exhaust Steam	60	
Tem Cool Water-Out	41	
Temp Hotwell Water	43	
Vacuum	25	

EXCITERS AND TRANSFORMERS (In Service — Full Black Line)

No 1 Exciter	19-25
No 2 Exciter	4-13
Unit No 5 Transformers Temperature	
No 6 Bank Transformers Temperature	
No 8 7 Bank Transformers Temperature	

SUBSTATIONS (Operating — Full Black Line)

Argo	14-30
Broadway	19
Clear Creek	19
Colfax	19
Delaware	13-10
Platte St Mill	24

CAR HEAT (Heat On — Full Black Line)

1st Point	19-25
2nd Point	
3rd Point	

BOILERS (Operating — Full Black Line)

	Hours
Boiler Feed Water Tem	
Steam Pressure	
Steam Temp	
Boiler No 14	8
Boiler No 15	13
Boiler No 16	24
Boiler No 17	
Boiler No 18	
Boiler No 19	
Boiler No	
Tem. Water to Boiler	
Temp Flue Gas	
Av. Flow Meter Reading	

MISCELLANEOUS BOILER-ROOM EQUIPMENT (In Service — Full Black Line)

Pressure Filter	24
Feed Water Heater	24
Boiler Feed Pump No 1	24
" " No 2	
" " No 3	
House Pump No 1	
" " No 2	
Stoker Motor No 1	24
" " No 2	8
Long Conveyor	2
Short Coal Conveyor	7
Short Ash Conveyor	0
Air Compressor No 1	7
Crusher No 1	
Artesian Well No 1	
" No 2	
River Pump No 1	
" No 2	
" No 3	

NAME — **ON DUTY** (Full Black Line) — **LABOR DISTRIBUTION** (12M 1 2 3 4 5 6 7 8 9 10 11 12N 1 2 3 4 5 6 7 8 9 10 11 12M)

Name	On Duty	Hours
W.E. Casey	Plant Supt.	9
E.G. Clemmons	Engine Room Foreman	9
J. Dean	Switch-Board Operator	8
Chas. Webel	" "	
J.B. Harvy	" "	8
Frank Tanson	Turbine Tender	8
A.J. Switzer	" "	6
O.J. Smith	" "	8
F.O. Dempsey	Boiler Washer	8
T.F. Scott	Steam Fitter	8
M.A. Davenport	Steam Fitters Helper	9
A. Benson	Boiler Room Repairman	9
	Extra	
	Extra River Pump Tender	9

BREAKERS OUT

Line	Time	Cause
16th St.	4.52 P	Ground
16th St. H.	7.10 P	"
10th St.	8.15 P	"
16th St. H.	8.51 P	"

Complete account of all interruptions:— No Interruptions

TOTAL LABOR HOURS 212

SUMMARY CHART

D.C. Gen. Output Today	None
" " This Month to Date	22850
" " Max Peak Today	
" " Load Factor Today	
A.C. Gen. Output Today	104500
" " This Month to Date	2703750
" " Max Peak Today	9300
" " Load Factor Today	45.9
Total Gen. Output Today	104300
" " This Month to Date	2728650
" " Max Peak Today	9300
" " Load Factor Today	458
Converted D.C. Output Today	43520
" " This Month to Date	1157040
" " Max Peak Today	3300
" " Load Factor Today	308
Purchased A.C. Consumed Today	16500
" " This Month to Date	257500
" " Max Peak Today	1750
" " Load Factor	393
Total Power Consumed Today	121000
" " This Month to Date	2985500
" " Max Peak Today	11150
" " Load Factor	49.2

LOAD CURVES

LEGEND— D.C. Gen.-Yellow Line, A.C. Gen.-Red Line, Total Gen.-Green Line, Delaware D.C.-Blue Line
Plot Highest Peaks Hourly in Pointed Curve-Thus ^^^
Plot Load Curve in Block Style-Thus ⌐¬

GENERAL DATA

	Shift 1	Shift 2	Shift 3	Total
City Water to Boilers-Gal				
Well Water to Boilers-Gal				
Eng Oil Used-Gal				
Cylinder Oil Used-Gal				
Temp. Max.-Min.	36-14	35.26	21.14	
Weather	Clear	Pt Cldy	Clear	
Height of River-Max Time				
Condition of River	Clear	Clear	Clear	
Pounds of Water/K.W.H.				

COAL DATA

Tons Ballance From Yesterday	580
Tons Mine Run Received Today	180
Tons Slack Received Today	
Total Tons Received Today	180
Tons Consumed Today	125
Ballance	635
Number of Cars Containing Slack	
Number of Cars Containing Mine Run	12
Tons of Ashes Today	
Pounds Coal Per Net K.W.H.	2.48
Pounds Water Per Pound Coal	

Signed

Operator Shift No 1

Operator Shift No 2

Operator Shift No 3

Approved Station Supt.

FIG. 3. DAILY LOG SHEET OF DENVER POWER DEPARTMENT

RECORD FORMS USED IN DENVER POWER PLANT IN CONNECTION WITH THE BONUS SYSTEM

Form 759 500 6-18

The Denver Tramway Company

CONDITION OF LOAD

Time 5.55 P.M. Nov. Date 27th 1918

	Avg. Load	Max. Peak	Machines in Service No. K. W. Cpy.
A. C. Generated at Platte	8000	9000	#8 7500
D. C. Generated at Platte			
D. C. Converted at Delaware	1500	1650	1500
Total System Load	9500	10650	9000

2 – 700 H.P. Boilers in service
1 – 700 " " Banked
" " "

Remarks: 12 Cars Leyden Coal

At top, daily report on load conditions.

In center, No. 8 turbine reports, a.m. and p.m.

At bottom, temporary watt-hour reading record later transferred to log sheet.

Form 850

The Denver Tramway Company

Date 11–27–18

Daily Report of { Steam Turbine No. 8 / Rating 7500 K.W.

Report by F. C. Lawson Unit Started 5.10 A.M. Shut Down 12.55 A.M.

LOAD READINGS

TIME	A.M.	7	8	9	10	11	12	1	2
Pressure	of Steam	180	185	190	175	175	180	175	185
	Degree Superheat	96	94	92	93	88	86	88	89
"	1st Stage	46	62	44	32	30	34	32	34
"	Absolute	.8	1.1	.1	.6	.6	.6	.7	.7
"	Barometer								
"	Pump	90	90	90	90	90	90	90	90
"	Bearings	25	25	25	25	25	25	25	25
"	Hydraulic Gear	90	90	90	90	90	90	90	90
Temperature return oil Gen. End		44	44	45	45	45	45	45	45
" " "	Middle	58	58	59	60	60	60	60	60
" " "	Eng. End	39	39	39	40	40	40	40	40
"	Oil Supply	49	49	49	49	49	49	49	49
"	Engine Room	72	72	74	74	74	74	74	74
"	Air in Gen.	14	16	24	30	34	36	36	36
"	Air out Gen.	74	74	76	78	78	78	78	78
"	Ex. Steam	74	82	72	66	66	66	70	72
"	Cooling Water inlet	33	33	33	33	33	33	33	33
" " "	outlet	51	52	52	46	46	46	48	48
No. Valves Operating		4	5	4	3	3	3	3	3
Kilowatts		7600	8000	6800	5000	4600	5000	5600	5200
Volts		108	108	108	108	108	108	108	102
Amperes		660	670	570	440	400	440	490	450
Field Excitation	Volts	92	92	90	90	90	90	90	90
	Amperes	270	270	260	210	200	200	200	205
Power-Factor		99	99	99	98	98	98	98	98
Speed		1500	1500	1500	1500	1500	1500	1500	1500

INSPECTION

Condenser and Pump	Main Governor	Steam Seal	Oil Pumps	Baffles	Strainers	Oil Filters
OK	OK	OK	OK	OK	OK	OK

Oil Filters	Wheel Clearance	Brushes	Generator	Collector Rings	Emergency Governor	Cleanliness
OK	OK	OK	OK	OK	OK	OK

REMARKS:

EC

Form 850

The Denver Tramway Company

Date Nov 27th 1918

Daily Report of { Steam Turbine No. 8 / Rating 7500 K.W.

Report by Albert Switzer Unit Started 5.10 A.M. Shut Down 12.55 A.M.

LOAD READINGS

TIME	P.M.	3	4	5	6	7	8	9	10
Pressure	of Steam	170 lbs	175 lbs	180 lbs	175 lbs	175 lbs	175 lbs	180 lbs	172 lbs
	Degree Superheat	93°	103°	91°	103°	98°	93°	91°	85°
"	1st Stage	38 lbs	50 lbs	60 lbs	55 lbs	40 lbs	30 lbs	20 lbs	22 lbs
"	Absolute Vacuum	.8	1.1	1.3	1.2	.9	.7	.6	.5
"	Barometer								
"	Pump	90 lbs	90 lbs	90 lbs	90 lbs	90 lbs	90 lbs	90 lbs	90 lbs
"	Bearings	26 "	26 "	25 "	26 "	26 "	26 "	25 "	26 "
"	Hydraulic Gear	90 "	90 "	90 "	90 "	90 "	90 "	90 "	90 "
Temperature return oil Gen. End		45°	46°	44°	45°	46°	46°	46°	46°
" " "	Middle	60°	60°	59°	59°	60°	60°	60°	60°
"	Gov. End	41°	41°	40°	41°	42°	41°	40°	40°
"	Oil Supply	46°	47°	46°	46°	47°	46°	46°	46°
"	Engine Room	72°	74°	76°	76°	78°	76°	76°	74°
"	Air in Gen.	30°	26°	24°	24°	24°	24°	22°	22°
"	Air out Gen.	76°	78°	80°	80°	80°	78°	76°	76°
"	Ex. Steam	74°	82°	86°	84°	74°	68°	62°	64°
"	Cooling Water inlet	35°	35°	34°	34°	34°	34°	34°	34°
" " "	outlet	50°	53°	56°	55°	52°	48°	46°	46°
No. Valves Operating		4	5	6	5&6	4	3	2	2
Kilowatts		6000	6000	7000	8000	5000	5000	5000	3000
Volts		108	108	108	108	108	108	108	108
Amperes		420	500	580	640	420	420	420	260
Field Excitation	Volts	88	90	90	92	88	86	84	88
	Amperes	220	240	250	270	220	220	220	180
Power-Factor		985	99	99	99	99	985	985	985
Speed		1580	1600	1500	1500	1500	1500	1500	1500

INSPECTION

Condenser and Pump	Main Governor	Steam Seal	Oil Pumps	Baffles	Strainers	Oil Filters
OK	OK	OK	OK	OK	OK	

Oil Filters	Wheel Clearance	Brushes	Generator	Collector Rings	Emergency Governor	Cleanliness
OK	OK	OK	OK	OK	OK	OK

REMARKS:

EC

Form 1015

The Denver Tramway Company

WATT-HOUR METER READINGS — PLATTE STREET POWER HOUSE REPORT — Date Wed. Nov. 27th 18

Time	A.C. Unit No. 8 Meter K= 1000		A.C. Unit No. 7 Meter K=		A.C. Unit No. 6 Meter K=		A.C. Unit No. 5 Meter K=		A.C. Total Nos. 6, 7 & 8 Meter K=		A.C. To Converter Meter K= 100		Argo Meter K= 100		Broadway Meter K= 100	
P.M.	Readings	K.W.H.	Readings	K.W.H.	Readings	K.W.H.	Readings	K.W.H.	Readings	K.W.H.	Readings	K.W.H.	Readings	K.W.H.	Readings	K.W.H.
3	70500										97100		9200		6500	
4	77000	6500									99500	2400	0100	900	7700	1200
5	84000	7000									02400	2900	1100	1000	9000	1300
6	92000	8000									05600	3200	2200	1100	0500	1500
7	98000	6000									08200	2600	3100	900	2000	1500
8	03000	5000									10200	2000	3800	700	3000	1000
9	08000	5000									12500	2300	4600	800	3900	900
10	12000	4000									14600	2100			4600	700

Time	Colfax Meter K=		Clear Creek Meter K=		D.C. Total Gen. & Con. Meter K=		D.C. Unit No. 4 Meter K=		D.C. From Converter Meter K= 1.6		D.C. Power & Lights Meter K= 100		Platte Street Transformer Temperatures			
P.M.	Readings	K.W.H.	Readings	K.W.H.	Readings	K.W.H.	Readings	K.W.H.	Readings	K.W.H.	Readings	K.W.H.	Bank No. 6	Bank No. 7	Unit No. 5	Rotary No. 3
3	9400		30000						90400		5850		25	25		27
4	0100	700	0500	500					91900	2400	5900	50	25	25		28
5	1000	900	1000	500					93600	2720	6000	100	28	25		32
6	2000	1000	1500	500					95400	2880	6100	100	30	30		36
7	2900	900	2000	500					96900	2400	6150	50	32	34		36
8	3500	600	2300	300					98100	1920	6175	25	30	30		32
9	4000	500	2600	300					99500	2240	6200	25		25		30
10	4500	500	2800	200					00700	1920	6250	50		25		28

Operator _____ Operator _____

FIG. 4. VARIOUS RECORD FORMS USED IN THE POWER PLANT

The coal used is a Colorado lignite with a heat value of about 9500 B.t.u. per pound as fired. The load on the power plant is purely a street-railway load, of familiar characteristic form. The guarantees for the large turbine and condenser and some tests on the boilers made it probable that it would be possible to produce a kilowatt-hour with 3.1 lb. of coal, as an average for a month, and this was adopted as the standard of fuel efficiency upon which to reckon the savings. If the large turbine is out of order and it is necessary to fall back on the auxiliary equipment, 4 lb. per kilowatt-hour is used as a standard. Fig. 5 shows a graphic illustration of the bonus scale.

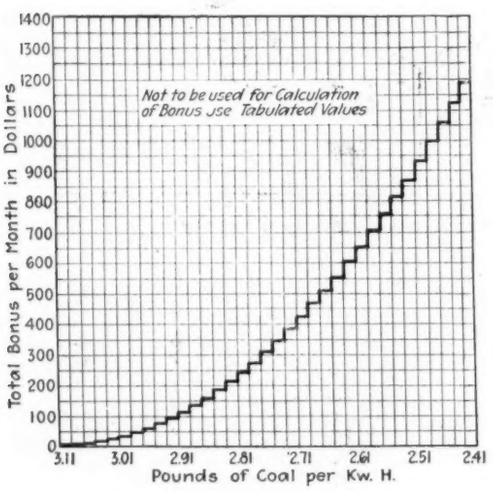


FIG. 5. THE BONUS CHART

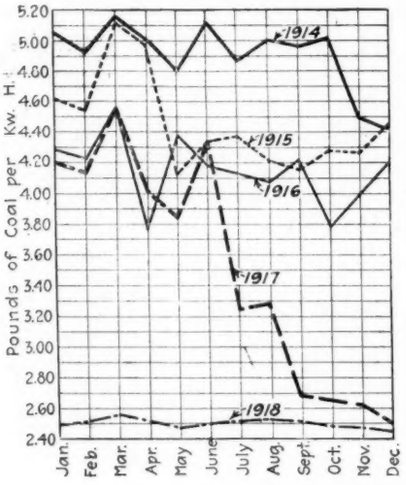


FIG. 6. COAL-CONSUMPTION CURVES

Many Checking and Economy Devices Installed

The possibility of earning a substantial bonus every month caused every man to consider the losses and how to reduce them. The activity in the boiler room, for instance, was concentrated on stopping air leaks on boiler and economizer settings, while the engine-room force made it a point to use the proper combinations of generating equipment in service. The log-sheet, Fig. 3, and other record forms, Fig. 4, indicate some of the checking devices installed to assist in the campaign to cut down the coal consumption per kilowatt-hour. In addition recording economy draft gages, thermometers, steam-flow meters and CO_2 recorders are in use. The CO_2 recorder is used as a portable checking device and in connection with the portable draft gage gives the desired information concerning the condition of the boiler setting, fire, etc. Flue-gas temperatures are taken at intervals. In the boilers the original Stirling arches have been replaced with flat arches both for reasons of increased economy of operation and because it was believed the flat arch would stand up better and longer. The flat arches have proved to be superior in both ways.

The result is that the new turbo-generator takes care of all demands and the balance of the generating equipment is held in reserve. Three 750-hp. Stirling boilers take care of the steam demands. Eleven 415-hp. Stirling boilers together with their equipment such as stokers, economizers, etc., have been removed and sold at a good price. Two more boilers of the same size, with economizers and chain grates and some extra chain grates, are for sale now, and as all this equipment is still in first-class condition, there is no doubt that it also will bring a good price.

The results obtained can probably be best illustrated by the attached chart, Fig. 6, showing the coal consumption per kilowatt-hour at the present time to be approximately 2.5 lb., in November actually reduced to 2.47 lb., which represents a saving in operating cost of approximately $150,000 per year. These results are due partly to the better economy of the large turbine and partly to some other less costly improvements in the boiler room, but in no small degree to the introduction of the bonus plan.

A few words concerning the adopted bonus system may be of interest. The coal consumption per kilowatt-hour is figured for the gross output of the station and includes all power used for the plant, amounting to 1.25 per cent. of the gross output. If the coal consumption for net kilowatt-hours is desired, the correction should be made.

One of the principles used in working up the scheme was so to arrange the bonus scale that the benefits derived from the special efforts of the employees would be satisfactorily shared between the men and the company, and it was also considered better and simpler to pay each man the same amount. This has amounted to about $35 per man per month above the regular salary. No special competition has been fomented between watches, but as the amount of bonus each will receive at the end of the month depends upon the combined efforts of all, no man is permitted by his companions to "lie down on the job." The daily logsheet, together with the coal book kept by the boiler-room foreman, gives the men all the necessary information so that they can tell where they stand to date on the bonus.

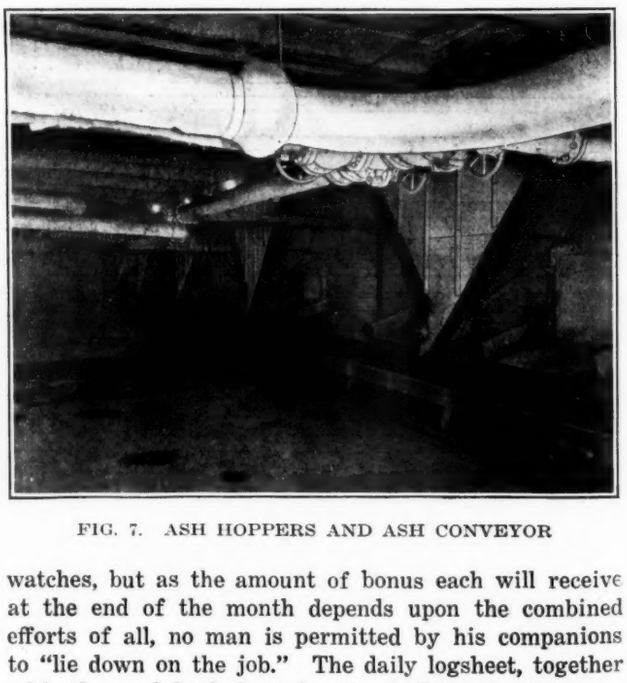


FIG. 7. ASH HOPPERS AND ASH CONVEYOR

It has been found that the wording of the bonus-system order offers sufficient restraint to prevent the employees becoming overzealous in their efforts, at the expense of the equipment. Thus, in accordance with the order, if No. 8 turbine has to be taken out of service for repairs, owing to faulty operation, no bonus is paid that month, and if damage is caused to the power house or any equipment through the fault of an employee, he is not entitled to participation in the bonus.

The bonus plan has now been in operation for a little over one year and no difficulties have arisen. This is probably due to the fact that the whole matter was placed before the men and discussed at meetings prior to the inauguration of the plan, as it was considered very necessary that each man should understand fully the method of calculating his share. One point of interest is that our experience at Denver indicates that it is not good practice to pay the bonus on the regular payday, for in spite of preaching and teaching some of the men form an idea that the bonus is simply wages and not an extra premium for increased efficiency. This point, as a matter of fact, reveals one of the danger marks of the whole bonus system.

Owing to the improvements made in the plant, an operating crew of only 25 men is now required, as compared with 55 men formerly. Shifts are now eight hours instead of twelve, and two weeks' vacation with pay is granted every man each year. Without doubt the incentive offered by a bonus has increased the economies, and it has also produced among the operating force a solidarity and coöperation which have improved the quality of power service. Cleanliness at the plant is considered a necessity. Inspection of all parts of the station is made with the greatest care, it being fully understood by the men that laxness may result not only in a pecuniary loss, but also in a loss in reputation reflected readily in a decreased amount of bonus earned.

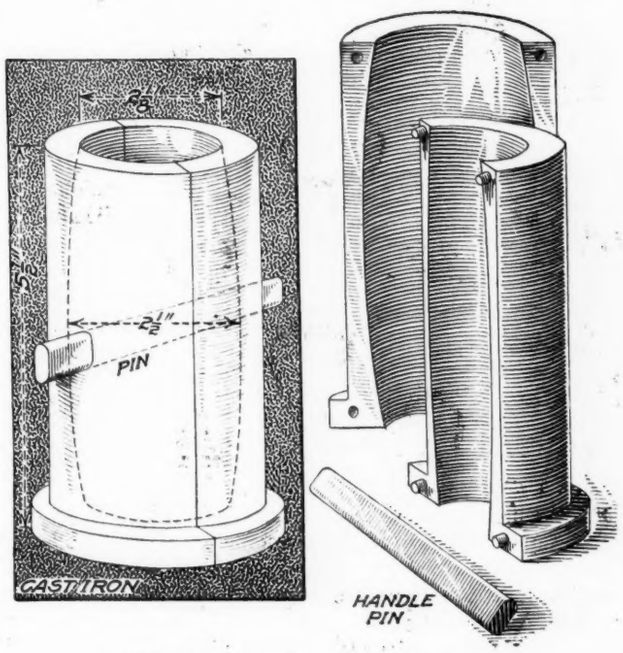
A great deal has been said in the past for and against bonus systems in general, and it is clearly understood that the same system is not suitable for every plant. In this case, however, the scheme adopted has worked out exceptionally well not only for both employees and employers, but also for the public in general, through a better utilization of coal and other materials and an increased reliability in the power supply.

Mold for Lead Hammer

Repairmen employed in large power plants find that babbitt hammers are useful because they do not batter the parts that are to be removed from or driven onto shafts, studs, etc. Naturally, a babbitt hammer does not last long, and it is the practice of some chief engineers to make their own.

In one plant new hammers are made by casting them in a cast-iron mold, which forms a hammer weighing 7½ lb. Its construction is shown in the illustration. It is split in two sections, the inner surfaces of which are turned out in a lathe to the shape of the exterior surface of the hammer, which is 2¼ in. diameter at the end; 2½ in. diameter at the center and 5½ in. long. The bottom of the mold is made with a flange so that it will stand on end while pouring the metal in at the top.

The halves of the mold are held together by means of a tapered oval wedge, shaped the same as the handle to be used, the wedge coming so as to form the handle hole in the center of the hammer. At the top and bottom of one half of the mold four holes are drilled and four corresponding pins are driven into the other



MOLD FOR CASTING LEAD HAMMERS

half. These dowel pins assist in keeping the two parts of the mold in place.

When ready to pour a hammer, the babbitt is heated to a temperatre sufficient to char a stick, and after cleaning the inside of the mold it is assembled and placed on a piece of sheet asbestos with a little putty around the edges of the flange. The metal is then poured level with the top of the mold, and when cool the pin is knocked out, the halves of the mold separated, and after removing the hammer, the operation is repeated until the required number of hammers have been cast.

Delegates to the Convention, National Association of Stationary Engineers

Power will again this year try to publish the photos of attending delegates in its convention fun maker, the *Power Pup*. Also each delegate will be given a package of cards bearing his photograph, name, position, association and city. But to do this we must have either your photograph or the electrotype we gave you at previous conventions, together with name, position, association and city.

All photographs must be of post-card size and show only head and shoulders—the three for a quarter kind will do. All photos must reach us by Aug. 20. No photos will be accepted at Huntington, as Huntington affords no facilities for making electrotypes.

Please call this to the attention of your fellow-delegates and mail your photograph or electrotype today. These cards will help you to associate the names with the faces of the many new friends you will make. Address, Editor of Power, Tenth Avenue at Thirty-sixth Street, New York City.

Electric Temperature Indicator

By VICTOR H. TODD

THERE are a great many places where it is necessary to have a continuous indication of temperature, but the desirable spot may be very inaccessible for reading a thermometer, should one be installed For instance, in chimneys, hot liquids, hot gases, heating ovens, etc., it is possible to install thermometers, but it is inconvenient to read them. In other places, such as in coal piles, bales of material which are liable to take fire by spontaneous combustion, windings in generators, transformers, etc., it is desirable to know the temperature at any time (generally at periodic intervals), but it is practically impossible to install thermometers. Electric temperature indicators not only indicate the temperature continuously at any particular point, no matter how inaccessible it may be after installation, but they may be placed in any convenient location, for instance, on the engineer's desk or on a wall panel. Fig. 1 shows one type of temperature indicator; this particular instrument gives a continuous indication of temperature.

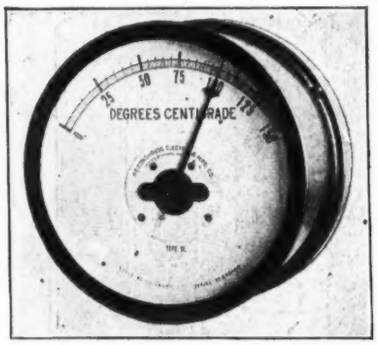


FIG. 1. TEMPERATURE INDICATOR

The temperature-indicator outfit consists of three main parts, which must be connected to a suitable source of direct current. They are the indicator, bridge arms (called the bridge box) and exploring coil. Advantage is taken of the well-known fact that the ohmic resistance of copper wire varies with the temperature. Consequently, if a coil of copper wire is embedded at the point where it is desirable to know the temperature, it is only necessary to provide means of measuring the resistance of the coil, and from this the temperature is determined. In actual practice it is not at all necessary to know the resistance in ohms of the coil, but since it is known that a given temperature produces a certain deflection on the indicator, due to a change in resistance, it is only necessary to mark this point as so many "degrees" of temperature and not so many ohms.

The apparatus is connected as shown in Fig. 2. The exploring coil is embedded at the desired point and connected with ordinary insulated copper wires to the bridge arms, *A*, *B* and *C*. These bridge arms are wound of resistance wire which has a negligible temperature coefficient (that is, its resistance does not change with varying temperature) upon insulated spools and inserted in a convenient housing, as shown in Fig. 3, which is called the "bridge box." Each resistor is carefully adjusted so that it is exactly equal to the resistance of the exploring coil at the point at which it must be most accurate. For instance, if an indication is desired from 30 to 130 deg. C. and 100 deg. C. is the most important point, then the resistance of the exploring coil would be determined at 100 deg. C., and each of the bridge arms *A*, *B* and *C*, Fig. 2, would be adjusted to exactly this amount.

In this case the pointer is mechanically set, by the spring or zero adjuster, to indicate normal temperature 100 deg. C., without current. Then a low-resistance (cold) exploring coil produces deflection to the left; equal resistance produces no deflection, so the indicator points to 100 deg. C.; and a high-resistance (hot) exploring coil produces a deflection to the right-hand side.

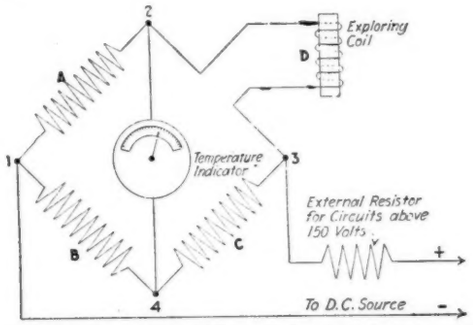


FIG. 2. DIAGRAM OF TEMPERATURE-INDICATOR CIRCUITS

The source of potential must be direct current and may be a constant-potential circuit of anywhere from 6 to 750 volts. Above 150 volts, however, it is necessary to provide another external resistor to limit the current. The supply leads are connected to points 1 and 3. The indicator is a high-grade direct-current voltmeter of the permanent-magnet moving-coil type. For ordinary applications the needle must deflect clear across the scale on 0.005 ampere. The indicator is connected to points 2 and 4 on the bridge box.

The exploring coil used for moderate temperatures is simply a strip of mica wound with a large number of turns of fine, insulated copper wire. This fine wire is welded to heavy leads which are mechanically anchored to the strip, and then, after a careful adjustment of resistance at a known temperature, the whole coil is impregnated in some heat-resisting compound.

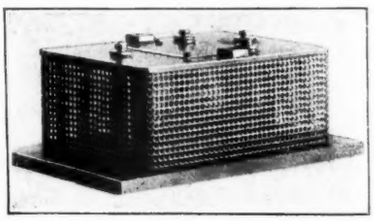


FIG. 3. BRIDGE BOX

For higher temperatures or for use in hot acids or gases which might destroy an unprotected coil, the exploring coil is wound, adjusted and sealed in a glass bulb from which the air has been exhausted in much the same manner as from an electric lamp.

The exploring coil or bulb is embedded at the point at which a temperature indication is desired and, as stated before, is connected by ordinary insulated copper wire to the bridge box and indicator. If the run is unusually long, a slight compensation must be made for the resistance of the connecting wires.

After adjusting the resistance of the exploring coil and bridge arms, the final calibration or checking is made experimentally by connecting all the apparatus properly and inserting the exploring coil in a hot oil bath and measuring the temperature with an accurate

thermometer. The oil should be stirred constantly while heating, and sufficient time must be allowed for the coil to reach a uniform temperature before checking a result.

In many cases it is difficult to remove an exploring coil for a test, but accurate constants can generally be obtained from the manufacturers which enable the indicator to be checked by substituting a variable resistance or ohm box for the exploring coil. If the coil measures, say, 23.5 ohms at 30 deg. C., then when the ohm box is connected in instead of the exploring coil and plugged to 23.5 ohms, the indicator should indicate 30 deg. In a similar manner, by plugging in resistance equal to that of the exploring coil at various temperatures, it is possible to indicate the corresponding points on the indicator.

be identical in adjustment to give correct results, but they may be situated at various places, widely separated if desired, and indicate the temperature of various points in rapid succession. Sometimes a multipoint switch is used, as shown in Fig. 5. Another method, which utilizes standard double-pole switches, is given in Fig. 6. To start a set of readings, all the switches are thrown down and then each one thrown up as a reading is taken. Care must be exercised that perfect contact is made on the switches, as a poor contact may introduce sufficient resistance to cause a wrong indication.

When near the balance or normal point it is hard to tell if the outfit is working properly or not, as the pointer will indicate balance even though there should be no control voltage. To insure against this, it is

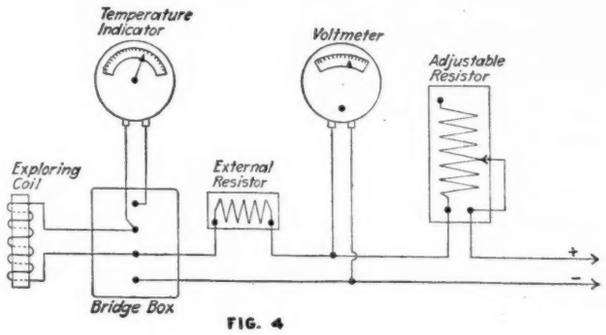


FIG. 4

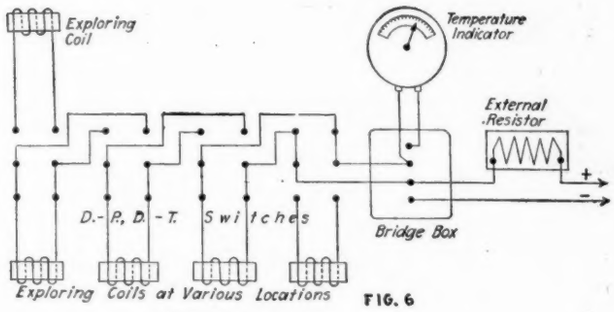


FIG. 6

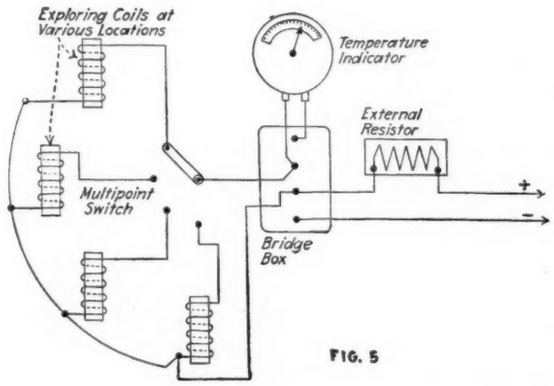


FIG. 5

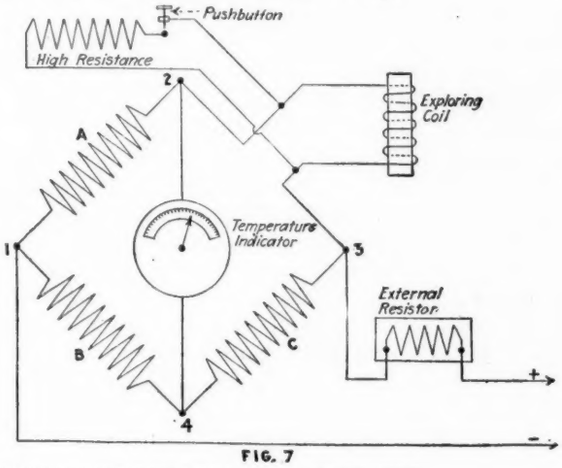


FIG. 7

FIGS. 4 TO 7. DIFFERENT METHODS OF APPLYING THE TEMPERATURE INDICATOR

At the point of balance a change in the control voltage cannot affect the reading, but when the pointer is nearing the ends of the scale, a change in control voltage will change the temperature indication. The tendency of low-control voltage is to indicate high temperatures below the balance point and low temperatures above this point, while high-control voltage tends to produce low readings below balance and high readings above balance.

If these readings are very important, it may be necessary to install an ordinary voltmeter to indicate the control voltage, and if this varies considerably, to install an adjustable slide resistor to take care of control voltage fluctuations when reading the instrument. As shown in Fig. 4 this resistance is inserted so that the voltage may be adjusted on both the temperature indicator and voltmeter.

Any number of exploring coils may be used to indicate on one indicator if provided with proper switching arrangements. Of course the exploring coils must

customary to install a test button, as shown in Fig. 7. This button is in series with a resistance of several hundred ohms, and when it is pressed, it places this resistance in parallel with the exploring coil. This has the effect of lowering the resistance of the exploring-coil circuit, and consequently if the outfit is working properly, the pointer will indicate about 10 per cent. lower while the button is being pressed. If there is no control voltage on, there will be no change in deflection, thus denoting that the instrument is not functioning properly.

By substituting a sensitive relay-type of graphic meter for the usual indicator, it is possible to get accurate records of temperature behavior over any period of time.

Instead of a graphic, a sensitive polarized relay may be used to give a signal or close an electric circuit upon high or low temperature, thereby putting in operation any kind of electrically controlled apparatus such as blowers or pumps.

Opportunities for the Trained Engineer

By L. W. ALWYN-SCHMIDT

"CHIEF, I am through with this job! I'm done with power-house work! I'm going to be a mechanic or something else that pays better. Why, even a riveter can make ten dollars a day."

Jim, the assistant engineer, was the speaker. He had come to the plant as the successor of a young man that had left to take a chief engineer's position, and though he was willing, diligent and intelligent, he was dissatisfied. The world seemed to hold so many positions more desirable than that of assistant engineer.

The chief looked him squarely in the eye for a long moment.

"What's the matter, Jim?" he asked. "Haven't I been treating you right? Aren't your wages fair?"

"It's not you, chief. You've treated me square, and the pay is all I can expect. But I'm tired of being an assistant all my life. I want to get on. I want ——"

The chief interrupted him with a raised hand.

"Just a minute, Jim. So that's the secret. You want to get ahead, eh? Well, I've got something to say to you, and you may as well sit down while I say it. You're 28 and not satisfied. You want to climb. To do that, you've got to deliver the goods. Now, what have you done so far? What do you know? Do you read? Do you study? Are you at this moment able to hold a bigger job?"

Jim fidgeted, but he made no reply.

"No, my boy," continued the chief, still in his kindly tone, "you know you are not prepared to go ahead. That's why you would throw up the sponge and try something different. Don't make that mistake. This engineer life is a fine one, and if you know your business you can make something out of it. Don't get the idea that all the good jobs will dry up. Remember what I say—in five years there will be ten jobs for power-plant engineers where now there are three, and young men will be in demand. But these men will be of a different type from us. They will be better taught and better paid. Don't throw away a good chance. Stick to your job!

"There are many like you just now—young men who might do well as chiefs and who have all the advantages of learning offered to them. But how many really succeed? They are lured away from their jobs by the attraction of higher wages. When the new jobs end they drift back again to the power houses, but find that they have forgotten much and that they are not so suitable for assistants as they once were. They are much less eligible for positions as chiefs. Many of them may find a footing in other fields, but most of them become permanently uprooted, and the good material that, if properly directed, would have made a first-class chief may be wasted in minor employments. It is very little satisfaction to get years of experience running a 500-hp. steam engine and end one's life tending an apartment-house furnace.

"During the year 1910, the last year when an occupational census was made in the United States, 135,000 electrical engineers, 230,000 stationary engineers, 111,000 firemen, 96,000 locomotive engineers and 76,000 locomotive firemen were counted. The number of engineers on American ships is not recorded by the census. It is difficult to compare the result of the census of 1910 with that preceding it, but estimates made by the census officials show that the number of men finding employment in occupations related to that of the power-house engineer and including power-house engineers has grown approximately 50 per cent. No doubt the employment rate in power-house work has increased very rapidly during the last eight years following the census of 1910, and it is very likely that it has far exceeded 50 per cent. Allowing, however, for only a normal increase, this would mean that at the present time there are 200,000 jobs for electrical engineers, which of course are not all in power-house work proper, 345,000 jobs for stationary engineers and 170,000 for firemen.

"These figures are borne out by another method of estimating. Of the 200,000 stationary steam engines employed in the United States, 75 per cent. most likely are of such size as to require a chief and an assistant, while the remaining 25 per cent. require only one man to look after them. We have, then, 150,000 steam engines each with two attendants, which accounts for 300,000 positions, and 50,000 engines with one man only, accounting for another 50,000 positions, or 350,000 positions in all. This is just 5000 positions more than the figure estimated on the basis of the natural growth of the industrial occupations in the United States.

"Every new power unit added in national industries means an increase in the demand for power-house engineers. We cannot build hundreds of new ships without also making provision for manning their engine rooms. Every new machine built by the railroads represents a drain on the number of available engineers.

"Assuming that of the 200,000 electrical engineers only 50,000 are employed in power-house work, and adding these to the 345,000 men employed in connection with steam-power generation, the total national power-house force amounts to 395,000 men. Death, retirement from work, and other natural and economic causes will reduce this number at the rate of approximately 6 per cent. every year, so that approximately 24,000 men are required annually to fill the positions vacated by others. Approximately the same percentage of new men will be wanted annually to take the new jobs resulting from the expansion of the use of power for industrial purposes; thus, 48,000 power-plant jobs are open in this country every year for new men.

"The position of the power-house engineer has grown a good deal in responsibility. There is no room now for the easy-going men of former times. The war has taught us the wastefulness of having men of this type operating the primary sources of our industrial power. The power-house engineer of today must be a man well versed in his profession. He must be something of an accountant, an economist and a teacher. Only if he combines all these qualities with those of a first-class engineering training will he be able to

fulfill all the duties required of him. How else can he trace the effectiveness of the power supplied by him from the power house to the machines? How can he arrange for the best application of the machinery in his charge, and how can he train a staff of helpers both in the power house and outside it to assist him in making the best use of the equipment?

"True, there are not many men to fit that description. Those available are quickly picked up by the large and progressive firms. But also the salaries offered for positions of this character are often not attractive enough to bring first-class men to the profession of power-house engineer. In time this condition will rectify itself. Factory owners will learn that a high-grade man, although probably costing more in the first instance, will in the end be less costly than a man commanding a smaller salary but deficient in knowledge. The one by his management will save more to the firm than he receives in additional salary; the other will cost too much, however cheap his price may be. The position is one which must be attacked from both ends. There must be an improvement in class and knowledge on the side of the engineer and a desire on the side of factory owners to employ men of better training. With coal prices where they are and where they will continue to be for quite a while, owners really cannot afford to employ any but the best-trained men.

"Men like you today have no excuse if they do not reach the higher positions, for there is plenty of room at the top. Education must be the ladder, and there is ample opportunity for obtaining education in this country. The engineer who finds time and leisure to visit the technical universities can get the teaching and the advice of the best engineers of the world. The man whose job holds him during the day finds free education in evening schools and public lectures. The man who cannot get away from his work at all, or whose circumstances will not allow him to attend school or lectures, has the assistance of correspondence schools and of many technical books written especially for the home student.

"The call for better education appeals not only to the young men but also to those who have been in service for many years. The war has shown the older men that they are more useful than they probably thought themselves. They have taken their stand in the second line and they have helped to fight the national battle as strongly and successfully as the youngest members of the engineering profession. No wonder that they are reluctant to relinquish the control they assumed while the young men were away.

"Unfortunately, not all of these older men had the training required for their work. When they were called to take leading positions they found they had to learn much that they thought was negligible. They have started to learn, and their new knowledge has been acquired while they adjusted themselves to the jobs. The work that has been done in this respect by the different agencies of the Fuel Administration no doubt will bear its fruit. It has shown the men the importance of their position and has added a new interest to their life. It also has provided a good deal of instruction, which should not be lost with the ending of the war. The engineering bulletins issued by the United States Fuel Administration will make useful reading for many years to come. They form an engineering library of enormous value to all who have to do with power-house work, and the different publications can be had at a price which hardly pays for a lunch.

"The war has brought the question of efficient power generating before the public eye, and the necessity of making savings has found more than usual discussion. The problems involved, however, are not connected with the war alone. They are in fact of considerably more importance during peace times, when the cost of producing energy becomes a matter of competition. The country that is able to produce industrial energy at the lowest cost will have a great advantage over the others. The question of whether our country shall stay in possession of its present export market and be able to increase it will be answered by the use we make of our large machine equipment. Ours is a country of high wages, and we are proud that our wage earners are better paid, lead healthier lives and are more prosperous than those in other countries. Nobody seriously wishes to change this; in fact, the tendency rather is to improve upon the present. So the machine equipment will have to help to remove the handicap of high wages in international competition. Human energy will have to be aided by machine energy. We shall want all the backing that our power houses can give us. They will be the basis on which we shall have to erect a structure of industrial and economic life.

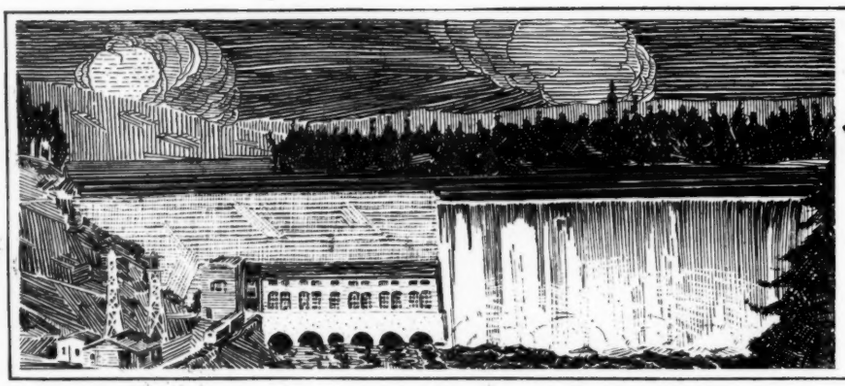
"That, Jim," concluded the chief, "is how I am picturing the future. The nation can use only big men to do this big job for her and chaps like you must not stand in the way. There are thousands of assistants ready to take jobs, and all of them, I am sure, will do their duty as conscientiously and as cleverly as you have done. But we do not want men who must be directed at every step. We need fully grown men—men who will keep that big plant out there doing the best that it can do. Jim, I want you to stay and be one of those men."

Jim stood quiet, his head bent. For a while the old dissatisfied expression clouded his face. Then it vanished, and he said: "I'll do it, chief!"

Difference in Boiler Prices

In reply to an inquiry sent out to boiler manufacturers for prices on a 72-in. x 18-ft. return-tubular boiler, 125 lb. steam pressure and per A. S. M. E. Code rules, the following prices were submitted by 26 concerns:

Key	Price Boiler	Gage Tubes	Price Fittings	Price Stack	Overhead, Per Cent.	Total
3	$1930.00	11	$622.40	$518.00	100	$3070.40
4	1975.00	11	739.42	627.00	180	3341.42
8	1908.00	11	506.00	408.00	....	2822.00
11	1936.96	11	733.81	473.27	175	3144.04
15	1904.20	11	619.80	597.90	150	3121.90
16	2219.68	11	328.47	347.66	150	2895.81
17	2100.00	11	583.00	386.00	150	3069.00
25	1788.77	11	456.98	382.54	175	2628.29
26	1847.77	11	494.19	426.60	180	2768.56
27	.....	..	.....	.....	....	3745.00
29	.....	..	.....	.....	150	2813.73
30	2320.00	..	125.00	391.00	175	2836.00
31	1603.82	11	612.32	406.00	100	2622.14
34	1826.36	11	577.75	388.86	....	2792.97
36	2570.00	..	200.00	575.00	....	3345.00
43	1803.35	11	377.32	375.34	....	2556.01
44	2078.14	11	485.82	506.30	....	3070.26
51	1919.31	11	675.05	553.26	100	3147.62
52	2076.90	11	288.65	248.00	180	2613.55
54	1725.44	11	376.03	197.04	160	2298.51
60	2454.08	11	398.35	406.54	150	3258.97
61	2138.00	11	643.50	313.85	60	3095.35
63	1982.37	11	389.61	415.59	175	2787.37
67	1879.20	11	463.28	Stack omitted	135	2342.48
68	1525.28	11	527.70	316.61	....	2369.59
73	1975.62	11	727.11	405.43	180	3108.16



POP'S WATER-POWER COURSE

By

John S. Carpenter

"JIMMY," exclaimed Pop, as he took a fresh chew and critically regarded the person addressed, "I guess our lectures are all off on account of the Board of Health's order agin the 'flu.' Public assemblages ain't allowed."

"Oh, Pop, don't say that. I don't see how any 'flu' germs could live in the same room with your and Jerry Geoghegan's pipes. And the rest of the fellows at the last lecture smoked such rank cigars that I feel pretty well sterilized and immunized."

"You're gittin' sorter finicky about your smokes lately since you got your raise," Pop allowed. "Better stick to old 'Sensation' and put the raise in War Savings Stamps. And while we're waitin' for them to lift the quarantine let's get down to our review. The subject," Pop announced with fitting gravity, "is how they find out what they got on a water-power site. The lecturer told us how the hydraulic engineer finds out how much water he's got to handle; how he checks the results by gittin' the average rainfall over as long a period as possible. Then he finds the area of the watershed or part of the country that drains into that river and multiplies that by the average rainfall, so finally he gits an idea of how much water he can figure per second after making allowances for leakage, evaporation, underground springs and a devil of a lot of other things. Agin the water he gits that way he compares the present flow of the river and makes allowances for flood and dry times, and the only way to git that is to find out from Si Perkins how high the water got when it washed away his chicken coops."

"What did he mean when he said they got the river flow by means of a weir?"

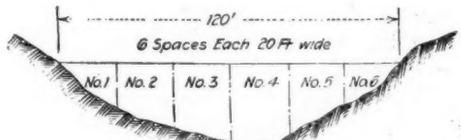
"A weir is nothin' but a board with a big enough notch cut in it so that water can all pass through the notch. That is, of course, when it's a small stream. For large streams they sometimes build weirs, but then it's almost a dam and it ain't easy. It's gen'ly easier to hunt a part of the river that runs pretty straight and then git the velocity by throwin' in floats and seein' how fast they travel per second. It's not as close as a weir, but if they do it right it won't be far off."

"He said something about current meters. How do they work?"

"Why, a current meter is only a fan wheel connected to clockwork that reads revolutions, and so many revolutions in so many seconds means that the water flows at a certain velocity at that point. Now, just to git the idea into my head I went up the creek Sunday afternoon and did the trick all by myself. I made three cross-sections of the creek, one down by the widder Jenks' farm, one at Casey's and the other at the sheriff's place. Here's what I mean by a cross-section." He showed Jimmy a sketch like that in the illustration. "You see, I measured off the creek into six parts of the same width and got the depths of each part. From that it was easy to find the area of each section. Then I used the current meter at a lot of different spots and I found that the water was movin' 2½ ft. per second. That was the average of the ten readin's I took. So then I made up a table like this:

Number of section	1	2	3	4	5	6
Width of section, ft.	20	20	20	20	20	20
Average depth, ft.	10	20	25	30	20	10
Area of section, sq.ft.	200	400	500	600	400	200

"You see, the area is just the width times the average depth. The area of the whole cross-section is



SECTION OF CREEK AT THE SHERIFF'S FARM

200 + 400 + 500 + 600 + 400 + 200 = 2300 sq.ft., and as the speed of the water is 2½ ft. per second the stream flow must be 2300 × 2½ = 5750 cu.ft. per second. Now then, I got the same kind of dope at all three places, and I compared the answers I got by multiplyin' the areas by the velocity in feet per second. They checked pretty fair."

"With a weir, Pop, I suppose it's generally accurate enough to make one weir and take one reading," Jimmy ventured.

"Gen'ly, unless it's for somethin' unusual. Now the Govamint has weirs in many parts of the country, what they calls gagin' stations, where they have a man stay and take readin's every day. Sometimes an engineer can git hold of somethin' like this and then his work is lot's easier."

"Do they have some kind of a wrist watch that tells how much water is going over the weir, or must it be figured out with a formula about the length of your arm?" asked Jimmy.

"They have a formuler, son, that neither of us could make head or tail of. I can't figger the three-halves power of a number and so I ast the lecturer if there was any tables and he said for us to write any of

the waterwheel builders for their catalog and you'd find it in the back."

"Of course, Pop, I can see that all rivers don't flow the same all year around, and that's why it's so hard to get the true average flow. He said that there's such a thing as overdeveloping a river and that it must be nice to find out that there is'nt enough water to run all your turbines!"

"Now with findin' the head," Pop continued, "there ain't so much guessin'. They just send a surveyor up the line with one of them three-legged things they calls a 'wye level' and he can tell just what the difference in elevation is, which is the head. He told us, though, that the condition of the river affects the operatin' head, for when the river rises the water backs up and so reduces the head. And at low water the head is the most, when you need it the most, too."

"I suppose that after the water passes through one set of turbines they can use it in another, like running a bleeder turbine off another or from a set of engines," Jimmy hazarded.

Pop eyed the offender thoughtfully. "No, Jimmy, you can't. When they takes all the pep out of the water, so that it just about creeps away from the turbines, it's done for. It's got to fall some more before it can do any more work. I thought you knew better."

"Excuse me for living, Pop," exclaimed Jimmy, "and don't look at me like that. What I was most interested in at the last lecture was how they fixed the sizes of the units. If there is about 5000 hp. wanted on the river, supposing that there's enough water, he said the best plan is to install three units of 2500 hp. each because when there's flood times the head is reduced quite some on a low-head plant and then the units won't give 2500 hp. each. Then is when the third turbine comes in very handy and delivers the balance of the power. Some engineers, he said, would make such a plant into four units and fix the units so that three would handle the 5000 hp. and the fourth would be a spare. Against this is the cost of an additional wheel-setting and a larger power house, by dividing them up into four units."

"What he said about speeds is about the same as buyin' motors," said Pop. "He said that wise engineers always git the highest-speed turbine they can because they cost less, all things considered."

"But what was that about the efficiency being bad on the higher-speed wheels?"

"You heard wrong," Pop declared. "He said that engineers and builders too used to think that the higher the speed of the turbine the worse the efficiency was, too. But now they make such good turbines that the efficiency is about the same whether it's a low- or high-speed turbine. You forgot too, that the reason for keepin' the units large when you were talkin' about three units for the 5000-hp. plant instid of four is that the efficiency is better with large-sized turbines than with small."

"He got off a pretty good one about the man who thought he could get as much power as he wanted out of the river by just putting in more turbines, when the stream was doing all it could and there wasn't a drop of water going over the dam."

Pop smiled reminiscently. "Reminds me of a mill man who kept puttin' on more pumps and engines onto the old biler and used to give me Hail Columbia because I couldn't keep the pressure up. Nope, puttin' orders through the purchasin' department won't git you any more juice unless it's there to git in the river."

"How'd you like a job on that high-head plant on Lake Leman in Switzerland he spoke of, Pop? Think of it. They got two tiny turbines under 3000 ft. head; nearly 1300 lb. per square inch pressure, giving 1000 kw. with a mere dribble of water!"

Pop allowed that there were safer places to work than that. "On the other hand," he said, "at that low-head plant in France, where they've got some turbines workin' under 16 in. of head, I'd be ashamed to take my pay if I didn't stand on a chair and help throw water into the turbines with a pail."

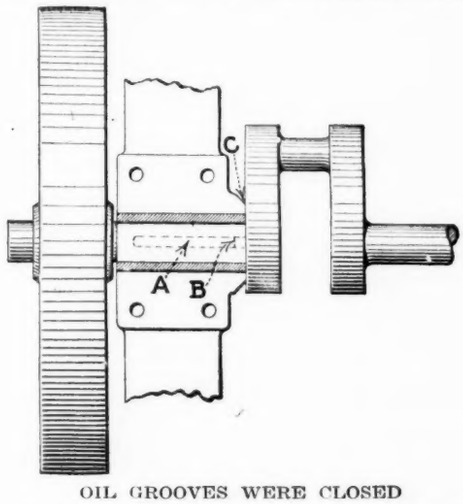
Just then the low-water whistle let loose on the south battery of boilers. Pop beat it in and frankly expressed his views to the ex-undertaker's assistant of a fireman. He emerged shortly with blood still in his eyes and resumed his chair. Jimmy busied himself with reading the announcement of the next lecture, while Pop gradually cooled down.

"Son," said the old man at length, "the next lecture's on the forebay, trash racks, log booms, penstocks and draft tube. We're goin' to strike the great divide then between the low-head and high-head plants. After we git through with turbines, the high-head work'll be next. So keep sober."

A Case of Oil Throwing

By P. A. Gett

A gas engine of the inclosed crank-case type developed a bad case of oil throwing from the flywheel, and I was called upon to correct the difficulty. An examination proved that the bearing had run hot enough to allow the babbitt lining to "wipe" over the oil grooves. There had been a groove in the bottom of the bearing, as shown at *A* in the illustration, and also a vertical groove in the end of the bearing at *B*, and the surplus



OIL GROOVES WERE CLOSED

oil supplied to the bearing had originally found its way back to the crank case through these grooves; but as both were now full of babbitt metal and the crank disk *C* rubbed the end of the bearing so closely that the oil could not get between, there was nothing it could do but run out at the other end of the bearing into the flywheel and from there to the four winds. Clearing the oilways corrected the difficulty.

The Electrical Study Course—Alternating-Voltage Cycles

Explains how, if the maximum voltage in the cycle is known, the voltage at any other part of the cycle can be easily calculated; also, how to determine the number of cycles of an alternator when the number of poles and speeds are known.

IN TWO of the previous lessons it was indicated that when a single conductor, as in Fig. 1, or an armature, with a complete winding, Fig. 3, is revolved in a uniform magnetic field, at a uniform rate, an alternating voltage is generated which may be represented by the curves, Fig. 2. Such a curve is known as a sine curve, or wave of alternating voltage or current. In this lesson it will be shown how the voltage generated in a conductor or armature is proportional to the sine of the angle that the conductor or armature revolves through.

Assume in Fig. 4 that we have one body moving around the circle *ABC* at a uniform rate of motion and that a second body is moving across the diameter *AC* at such a rate as always to be in the same vertical plane with the body moving around the circle. That is, when the body moving around the circle is at *a* the body moving across the diameter is at *a'*, or when the body moving in the circular path is at *b* the one moving across the diameter is at *b'*. From this it is evident that if the body traveling around the circle is moving at a uniform rate, the one moving across the diameter is moving at a constantly changing rate, being zero at *A*, increasing in speed until a maximum is reached at *O* and decreasing to zero again at *C*. At the instant that the two bodies are in the vertical plane *BO*, they

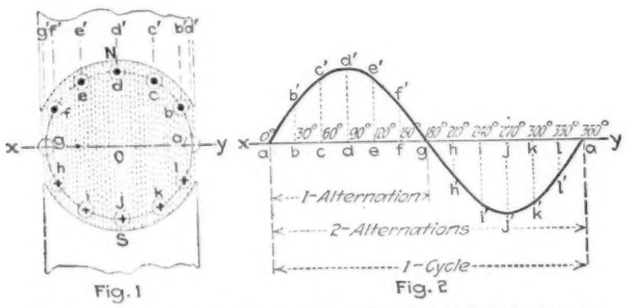


Fig. 1 Fig. 2

FIGS. 1 AND 2. CONDUCTOR IN A MAGNETIC FIELD AND VOLTAGE CURVE

are both moving at the same rate, therefore the maximum rate at which the body moves across the diameter is equal to the uniform rate the body moves around in the circular path.

What we have just seen in Fig. 4, regarding the rate of motion of the body moving across the diameter, is identical to the rate at which the conductor in Fig. 1 is cutting the lines of force. In Fig. 1, if we had a second conductor moving across the diameter *xy* at a rate that it would always be in the same vertical plane as the one moving in the circular path, they would both be cutting the lines of force at the same rate, being zero at *a*, increasing to a maximum in the vertical plane *dO*, and again decreasing to zero at *g*. Consequently the voltage (which varies with the rate of cutting the lines of force) generated in the conductor will vary from zero at *a* to a maximum at *dO*, and back to zero at *g*.

It has also been stated that if the radius of the circle above which the conductor revolves represents the maximum voltage, the vertical distance between the conductor and the diameter at any instant will represent the voltage generated in the conductor at this instant. Further consideration of Fig. 4 will show why this is so.

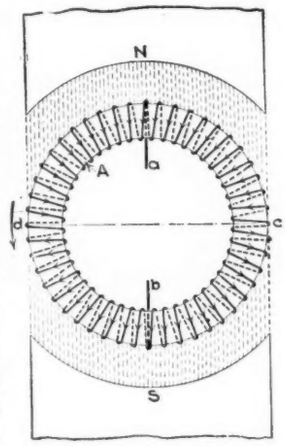


FIG. 3. ARMATURE IN MAGNETIC FIELD

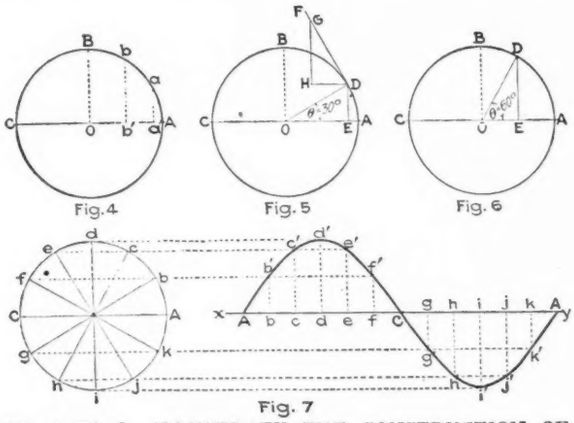
In Fig. 5, which is the same as Fig. 4, consider the instant when the body moving in the circular path is at *D*. The direction of motion at any instant of a body moving in a circle is at a tangent to the circumference; that is, at right angles to the radius. Therefore, in Fig. 5, if we draw a line *DF* at right angles to the radius *DO*, it will represent the direction the body is moving in at this instant. On *DF* lay off *DG* equal to the radius of the circle which we have assumed to represent the rate at which the body is moving; then *DG* will also represent the rate at which the body is traveling around the circumference. Draw *DH* parallel to the diameter *AC* and let fall a perpendicular from *G* to *DH*, thus forming the right triangle *DGH*. Now, if *DG* represents the rate of motion of the body revolving around the circle, *DH* will represent the rate of motion of the body moving across the diameter at this instant; that is, if the body moving around the circle is traveling at a rate that will carry it from *D* to *G* in a given time, the body moving across the diameter will be moving at a rate that will carry it from *D* to *H* in the same period.

From inspection it is evident that triangles *DGH* and *DOE* are similar. This is also true from the fact that the sides of the two triangles are perpendicular to each other, that is *DG* is perpendicular to *DO*, *DH* to *DE* and *FH* to *OE*. We might use *D* as a pivot and turn triangle *DGH* on, and move it around to the left until *DG* coincided with *DO*. Then *HD* would fall upon *DE* and *GH* on *OE*. Then, since *DH* represents the rate of motion of the body moving across the diameter, *DE* and perpendicular distance between *D* and the diameter which is equal to *DH* will also represent the rate at which the body is moving across the diameter at this instant. In the last lesson we found that the sine of angle θ is equal to $\frac{DE}{DO}$, from which $DE = DO \sin \theta$. If we asume that the body moving in the circle is traveling at the rate of 15 ft. per sec., which is also the maximum rate across the diameter *AC*, and let the radius *DO* represent this rate, and at this instance let angle θ

be 30 deg.; then the rate at which the body is moving across the diameter is $DE = 15 \sin 30$ deg. Sin 30 deg., from the table given in last lesson, is found to be 0.500; therefore $DE = 15 \times 0.5000 = 7.5$ ft. per sec. This must not be confused with the distance traveled, as the body has moved only the distance AE, which in this case is about 2.1 ft., but in moving this distance the body has been accelerated to about 7.5 ft. per sec. At 60 deg., Fig. 6, $DE = OD \sin 60$ deg. $= 15 \times 0.866 =$ 12.99 ft. per sec., and the body has moved the distance AE, or 7.5 ft. In each case the rate of the body moving along the diameter AC is proportional to the sine of the angle through which the body traveling around the circle has moved.

From the foregoing it is evident that a curve, representing the rate at which the body is moving across the diameter when the radius represents the maximum rate, may be constructed by laying off equal distances *Ab, bc, etc.*, on the line *xy*, Fig. 7, representing the divisions of the circular path, at these divisions erecting verticals and projecting from the divisions on the circle to intersect the verticals at b′, c′, etc. By joining the points thus obtained a curve representing the rate of motion of the body across the diameter will be the result. Since the vertical distances between the curve and the line *xy* is proportional to the sine of the angle that the body moving around the circle passes through, the curve is called a sine curve.

What we have just seen is that a body traveling around in a circle at a uniform rate has a rate of motion parallel with the diameter of the circle which is proportional to the sine of the angle through which it passes. Therefore, if a conductor is caused to travel in a circular path, as in Fig. 1, at a uniform rate, it will be cutting across the magnetic field at right angles to the lines of force at a rate proportional to the sine of



FIGS. 4 TO 7. ILLUSTRATE THE CONSTRUCTION OF A SINE CURVE

the angle moved through, hence the voltage generated will be proportional to the sine of the angle. It is for this reason that the voltage or current wave obtained from a conductor revolving in a uniform magnetic field is called a sine curve. This is also true for the voltage generated by a number of conductors in series on an armature. In Figs. 8 and 9 of the lesson in the July 15 issue, the voltage was found to be 73.62 when the armature had revolved to 30 deg. from the zero position, 132.7 when the armature was at 60 deg. from the zero position and 153.32 at 90 deg., or at the position of maximum voltage. By multiplying the maximum voltage 153.32 by the sines of angles 30 and 60 deg., which are 0.5000 and 0.8660 respectively, we have $153.32 \times 0.5000 = 76.66$ and $153.32 \times 0.8660 = 132.7$; these correspond to the values obtained by the measurements methods in the previous lesson. Therefore in any armature generating a voltage that varies according to a sine curve, if the maximum voltage is known, the voltage generated at any other instant is equal to the maximum voltage times the sine of the angle the armature has revolved through, in electrical degrees, at the instant when the voltage is calculated.

The line *xy*, Fig. 2, may be considered as representing the degrees, as shown, since it represents the distance the conductor moves in generating one cycle. In Fig. 1 the conductor made a complete revolution for the voltage to pass through one cycle, but this is true only in a two-pole machine. If the machine had four poles, when the conductor passed two of them or made a half-revolution, the voltage would have passed through one cycle, consequently two cycles in a complete revolution. In other words, the voltage passes through a cycle each time the conductor passes a pair of poles. Then it is evident the cycles per revolution equal the number of poles, *P*, divided by 2; then the cycles per minute would equal the cycles per revolution times the revolutions per minute, *S*, or $\frac{P}{2} \times S$. The cycles of any alternating-current circuit is usually expressed as so many cycles per second and will equal the cycles per minute divided by 60. Thus, if we let *f* equal the frequency, the cycles per second, we have $f = \frac{P}{2} \times \frac{S}{60}$ or $f = \frac{PS}{120}$. This is the same as saying that the cycles per second (f) of any alternator-current generator are equal to the number of poles (P) times the number of revolutions per minute (S) divided by 120. The frequency of an alternating-current generator having four poles and running 1800 revolutions per minute will be $f = \frac{PS}{120} = \frac{4 \times 1800}{120}$ $= 60$ cycles per second. Since a cycle equals two alternations, the voltage will be changing its direction $60 \times 2 = 120$ times per second.

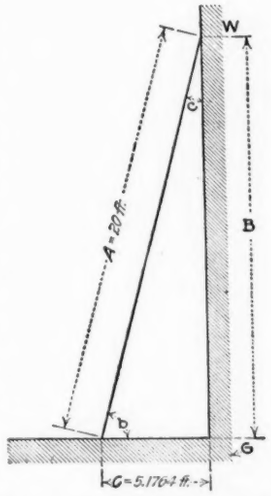


FIG. 8. DIAGRAM REPRESENTING LADDER AGAINST WALL

The problem of the preceding lesson was to find how high up a wall a 20-ft. ladder would reach if its foot were placed 5.1764 ft. away from the wall. Also to find the angle that the ladder makes with the ground and the one it makes with the wall. In Fig. 8 let *A* be the ladder, *W* the wall, and *G* the ground. *A* is given as being 20 ft. and *C* as 5.1764 ft. It is required to find *B* and the angles *b* and *c*. Since *A*, *B* and *C* form the sides of a right-angle triangle, we know that $A^2 = B^2 + C^2$ so that, by substituting the known values, we have $(20)^2 = B^2 + (5.1764)^2$. Squaring the quantities gives us, $400 = (B)^2 + 26.7951$, from which we get $(B)^2 = 400 - 26.7951 = 373.2049$ and $B = \sqrt{373.2049} =$

19.3185 ft. To determine the angles b and c we make use of the fact that sine $b = \frac{B}{A}$ and sin $c = \frac{C}{A}$. Thus we have, sin $b = \frac{19.3185}{20} = 0.9659$ and sin $c = \frac{5.1764}{20} = 0.2588$. Looking up the angles corresponding to these values in the table published last week, we find that 0.9659 = sin 75 deg. and that 0.25882 = sin 15 deg. Consequently $b = 75$ deg and c 15 degrees.

Since sides A and C were known, we can find the sine of angle c first, which we have already found to be $\frac{C}{A} = \frac{5.1764}{20} = 0.2588$, equals sin 15 deg., that is angle c equals 15 deg. and angle b will equal 90 — 15 = 75 deg. Then $B = A \sin b = 20 \times 0.9659 = 19.318$ ft., as obtained by the other method.

1. In Fig. 2, if the maximum voltage is 250, what will the instantaneous value of the voltage be at 25 and 65 deg. of the cycle?

2. An alternator has 16 poles and runs 187.5 revolutions per minute. Find the frequency in cycles per second, also the number of alternations per minute.

Crankshaft Successfully Welded

An example wherein welding has quickly and successfully restored to operation and added years of service to large crankshafts that have been broken by overloads is shown by the accompanying illustrations of a repair on one of two crankshafts at the South Norwalk Electric Works, South Norwalk, Conn.

During a heavy load season at the close of 1915 and the beginning of the year following, this company had the misfortune to have the mainshafts break in two of its largest engines within two months of each other—one in its largest steam engine and the other in one of the Diesel engines. The first break was

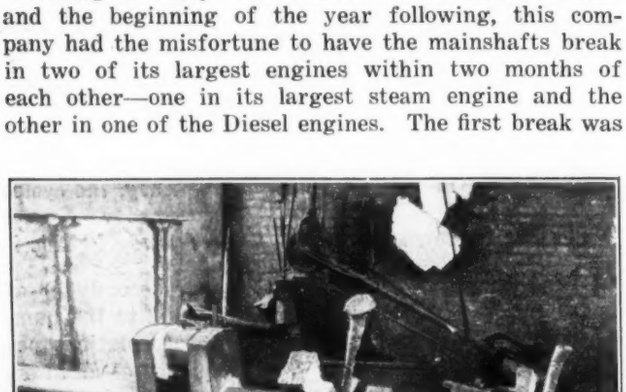


FIG. 1. TWO THERMIT WELDS ON A 9-IN. DIESEL-ENGINE CRANKSHAFT BEFORE RISERS AND POURING GATES WERE CUT OFF

discovered just as the yearly peak load was well under way. A new shaft could not be purchased as there were none like it on the market and the already overburdened manufacturers of such parts could not warrant reasonable delivery. The situation was especially serious because the company not only supplied a considerable lighting business but also furnished power for the operation of approximately one hundred important local industries, all of which were at their busiest period. It was finally decided to have the shaft Thermit welded. This was done and the crankshaft was soon returned as good as new.

To those who are unfamiliar with the Thermit process, it may be explained that Thermit is a mixture of aluminum and iron oxide. This mixture can be ignited by means of special ignition powder and on reaction produces superheated liquid steel and slag (aluminum oxide), at a temperature of approximately 5000 deg. F. This Thermit steel is sufficiently hot to

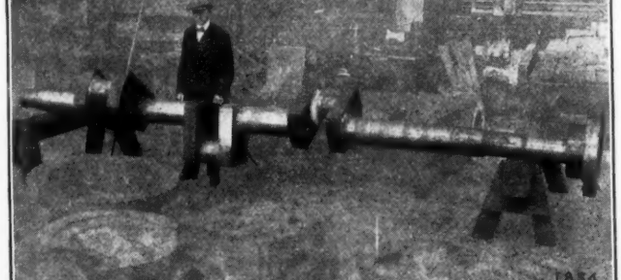


FIG. 2. CRANKSHAFT AFTER THE THERMIT WELDS HAD BEEN MACHINED

melt and dissolve any metal with which it comes in contact and amalgamates with it to form a solid homogeneous mass when cool.

In making the crankshaft repair, the broken sections were lined up together so that a small gap was left between the broken ends. This gap was filled with yellow wax and a mold box built around the broken ends. Gasoline and compressed air preheating torches were then directed into the mold, serving the triple purpose of burning out the wax to provide space for the Thermit steel later to enter, preheating the parts adjacent to the weld sufficiently to permit a more uniform contraction on cooling, and drying out the mold. The Thermit steel generated by the reaction was then poured from an automatic crucible into the welding space and allowed to cool and the excess metal formed by pouring gates and risers cut off. The function of a riser is to hold a supply of liquid steel which will feed into the weld during shrinkage and thus fill up any pipes that may form in the weld. It also acts as a depository, allowing any foreign material to be washed out of the weld into the riser.

Later, one of the large Diesel engine shafts developed a fracture in the throw of one of its cranks, and upon further examination, it was found that another crank was also fractured. This shaft, shown in the illustrations, was welded in its two broken locations with excellent results.

The unavoidable distortions by reason of inequalities in heating and cooling were so small as to be readily remedied by truing up the shaft in the lathe with a simple light cut where needed. This work was done by the repair company, while it was only necessary for the operating company to babbitt the main boxes, scrape in the shaft and refit the crankpin boxes.

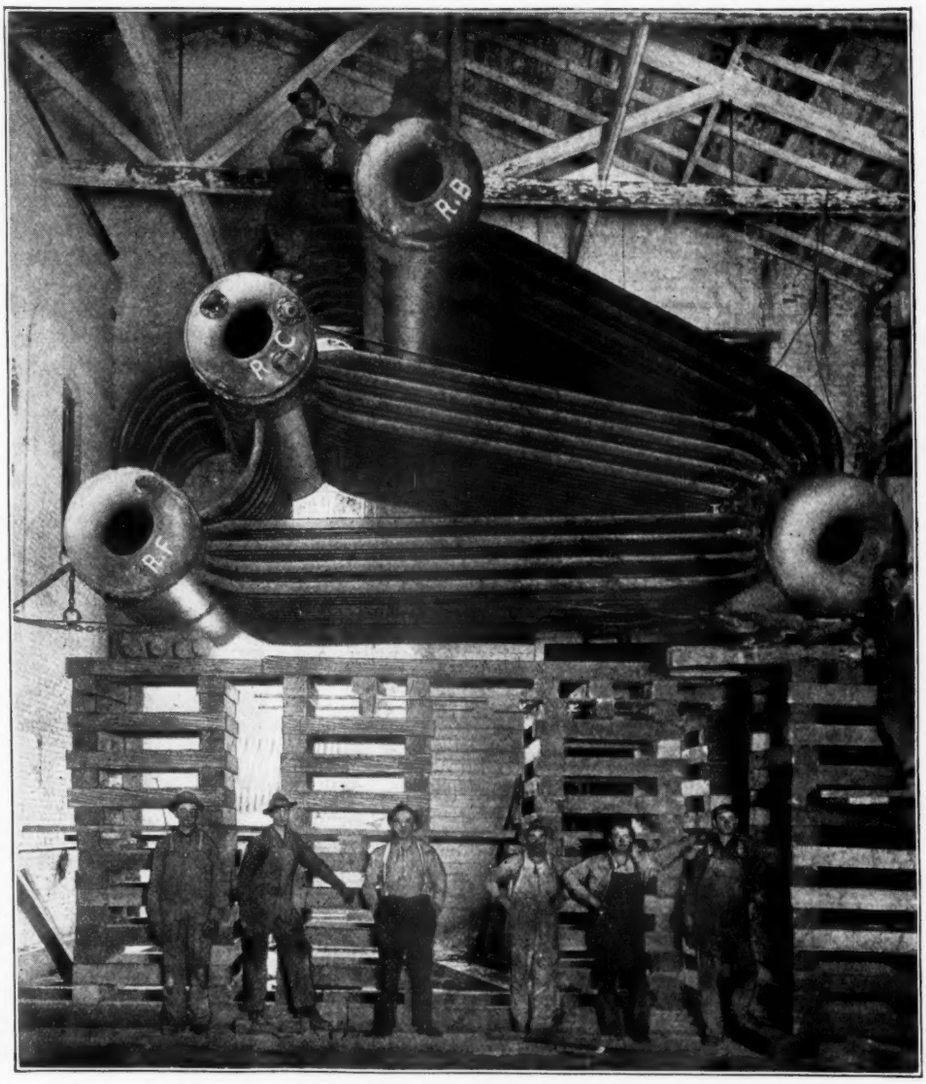
According to very recent reports from Albert E. Winchester, general superintendent of the company, the big steam engine stands ready with its other auxiliaries for immediate service, while the Diesel engine has been in faithful operation most of the time since its shaft was mended over three years ago.

Water-Tube Boilers Are Successfully Removed Intact

By Clifford A. Elliott*

After removing a steel smoke-stack by auto trucks from the Vineyard power plant of the Pacific Electric Railway Co. to the Torrance plant of the same company, occasion arose to move to Torrance two 250-hp. Stirling boilers that were no longer giving service at the Vineyard plant. It was first thought impossible to release each boiler complete, consisting of four 24-in. drums with its numerous 3-in. tubes. If the tubes connecting the four drums, as shown in the illustration, had been cut and again welded into place, it would have cost approximately four thousand dollars to remove the two boilers complete in this manner. The contractors who had successfully handled the removal and relocation of the steel smoke-stack were able to take the contract to handle the removal of the boilers intact, thus saving considerable time and expense.

The first steps taken consisted of releasing each boiler complete from its permanent position on a brick foundation, at which time the bolts were removed from steel frames set in brick enclosures, which frames supported the boilers and held them in place. The next step was to elevate the rear end of the boiler to the level of the front end; after which they would set up the first cribbing, move the boiler on rollers across the steam mains without touching these mains; thence over additional cribbing to a point opposite a door in the side of the concrete wall of the power plant, which was enlarged, a 4-ft. jamb 10½ ft. high being necessary, the jambs being taken out in two pieces. It will be observed from the illustration that as each unit of cribbing was set up, all units were tied together by longitudinal timbers set in the cribbing when and where necessary, so that in the event that the boiler should fall when being skidded via rollers over cribbing, it would carry all cribbing when falling. A donkey engine located on a flat car on a spur track opposite the plant carried a cable line in through a side-wall window for towing the boiler on rollers over planking placed on top of the cribbing. The maximum height of the cribbing units was 10½ ft. When the boiler was brought to a point opposite the door, it was lowered by sectional units of the cribbing being removed, then turned at right angles to the door and moved on rollers or skidded out of the building, where it was again moved on rollers up an improvised timber incline over an 8½-ft. retaining wall, from which it was moved upon a steel flat car for shipment to Torrance. It was transported to Torrance by special arranged service, as because of possible impaired clearances it was deemed inadvisable to transport it via regular freight-train movement. The approximate weight of each boiler complete was 47,000 lb.



STIRLING BOILER, 250 HP., BEING REMOVED INTACT

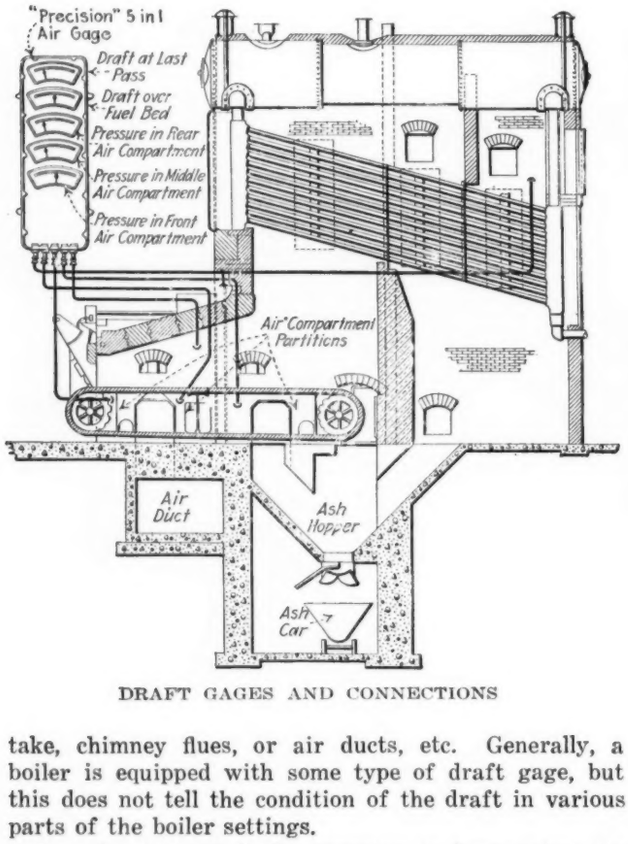
Four steel flat cars were required to handle the two boilers complete. One car was assigned to each boiler, the third car for valves, door fronts and miscellaneous other parts, and the fourth car for the breeching, donkey engine and hoisting equipment, cribbing and tool outfit of the contractors.

Allen Brothers, of Los Angeles, were the contractors who handled the removal and relocation of the boilers. The most important factor in this successful moving operation is the three-point suspension method of moving.

*Cost Engineer, Maintenance of Way Department, Pacific Electric Railway Co., Los Angeles, Calif.

Five-in-One Draft Gage

Draft losses in boilers depend upon the type of baffling and the condition of the fuel bed. High resistance may be caused by too thick a fuel bed, slag in the air spaces in the grate or air spaces too small for the coal used. Dirty flues and tubes also are a contributory cause. Draft may be reduced by doors being open in the uptake, chimney flues, or air ducts, etc. Generally, a boiler is equipped with some type of draft gage, but this does not tell the condition of the draft in various parts of the boiler settings.



DRAFT GAGES AND CONNECTIONS

In order to permit the operator to know what the draft and air pressure are at every point, the Precision Instrument Co., Detroit, Mich., has developed the "Five-in-One" draft gage, which is connected to the boiler setting as shown in the illustration. The gage tells at a glance the pressure at the first, second and third air compartments, the draft over the fuel bed and the draft at the last pass. If a hole develops in the fuel bed, the gage shows it instantly by the needle on one of the three lower dials, dropping back toward zero, and it not only tells of the existing hole but also where to look for it.

Referring to the top gage, which is connected to the draft at the last pass, the operator should keep the needle low so as to reduce the chimney-gas loss due to excess air. The needle of the second gage from the top registers the draft over the fuel bed and should be kept near zero on the draft side. If the needle gets on the pressure side, the burning gases will be deflected downward and upon the stoker parts and brickwork. The third gage indicates the draft at the rear compartment of the windbox, the next one the draft at the center of the windbox, and the bottom one the draft at the front compartment of the windbox. The operator should keep the needles of the three lower gages at points determined by experience or tests. If the fire side of the boiler is dirty, this cannot be done without forcing in air on the pressure side.

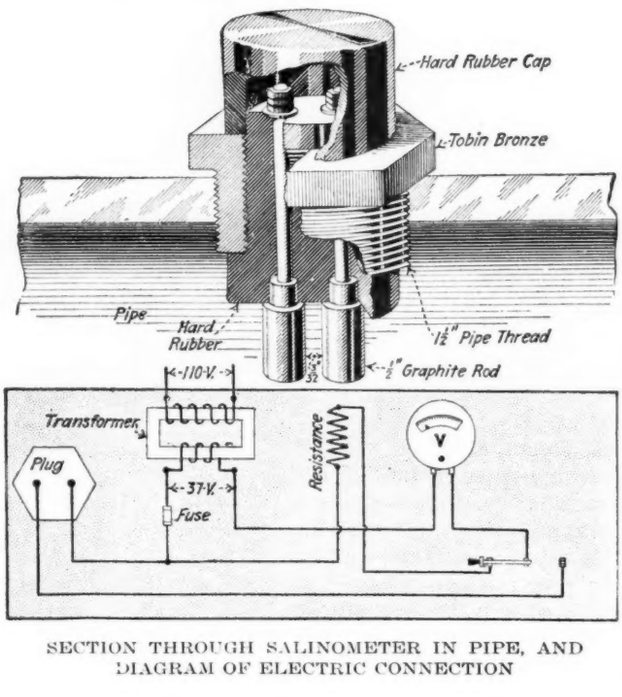
The standard readings for the stoker draft are 0 to 2 in. of water for the flue, 1 in. vacuum to 1 in. pressure for the combustion chamber, 0 to 6 in., 0 to 4 in. and 0 to 1½ in. for the front, center and rear air compartments, respectively.

Variations in pressure or vacuum are transmitted by the diaphragm through a vertical adjustable plunger attached to a horizontal shaft by means of a link or lever adjustable in length. At the side of the case are screw adjustments by which the operator may bring the pointer to zero when necessary. There are five main adjustments, which enable the movement to be calibrated to dead accuracy at every division. The gages are supplied in black enameled cast-iron cases and are dustproof.

Salinometer for Power-Plant Use

BY H. S. KNOWLTON

The Chile Exploration Co. is using an electric salinometer, illustrated in the accompanying diagram, for testing boiler-feed water and checking the leakage of condenser tubes. The apparatus, which was built by Thoner & Martens, Boston, Mass., from original designs of the Edison Electric Illuminating Co., of Boston, consists mainly of a plug with two graphite electrodes, which is inserted in the feed-water piping, the carbons being mounted at the bottom of a hard-rubber block through which metal terminal rods are run to binding posts at the top, inclosed by a hard rubber cap. A transformer reducing the potential to 37 volts from the ordinary 110-volt service is provided with a voltmeter and resistance for comparing the drop across the salinometer terminals with previous calibrations.



SECTION THROUGH SALINOMETER IN PIPE, AND DIAGRAM OF ELECTRIC CONNECTION

Governor Smith of New York has approved a bill proposing elimination of adult illiteracy in state. The new law appropriates $100,000 for the Americanization plan outlined by the Board of Regents. There are about 600,000 persons in the state unable to speak English and about 350,000 unable to read or write any language.

EDITORIALS

The Price of Coal

SENATOR Frelinghuysen has introduced a resolution providing that, whereas the price of coal has continued to rise without any apparent economic or other proper reason therefor, the Committee on Interstate Commerce be instructed to make inquiry into the causes which have brought about the enormous increase in the market price of coal with a view to determining who or what may be responsible for such increase in price, and whether it is due to economic causes or to manipulation and profiteering; and with a view further to recommending either Congressional or Executive action in order to remedy the existing conditions and bring about the punishment of any individual or corporation deemed guilty of unlawful acts.

Power readers, the largest purchasers of coal, will be interested in the progress of this bill and of the investigation that it authorizes. The fuel supply is one of the first requisites in the industrial and domestic life of a people. It is unthinkable that its purveyance should continue to be left to the uncontrolled manipulation of those whose only interest is to make its handling yield the greatest amount of profit to themselves.

This bill interests others than the user of coal for manufacturing and power purposes. The price of coal bears upon everybody. It is a factor in the production, transportation or distribution of everything that one buys. Higher prices paid for coal furnish a legitimate reason for an increase in the price of everything else.

With the application to the eternal struggle against the forces of nature of accumulated knowledge and experience and scientific discovery; with the employment of the marvelous tools and machinery at our command; with facilities for handling, storing and distributing which have never been equaled; with uses found for a large portion of the product formerly thrown away; with all of the economies of aggregation which should result from doing things upon a big scale—why should the public be paying the present prices for the service of mining coal?

For it is for the service and not for the coal that the public is paying. The conception that a group of men could fasten upon a natural resource like coal and dole it out at a price imposed by the necessities of their fellow-man is too repugnant to modern ideas of the relation of the rights of property to the rights of man to be contended for. What the coal operator has a right to charge is the cost of the service that he renders in maintaining his mine in working condition and getting coal out of it, plus a fair profit on that cost. The cost of rendering that service ought to be demonstrable before such committee as Senator Frelinghuysen proposes. The profit, not the price, ought to be fixed. Everybody expects the operator to make a fair profit as the condition of continuing to operate, and is willing to pay such fair profit. It may be that such an investigation as this bill proposes would reveal the fact that the operators are making only a fair profit. If it did, it would relieve a very widespread sense of resentment and imposition, and the public would adjust itself to the carrying of the necessarily high prices with resignation if not with contentment. But if it should not, no sophistic cant about the rewards of initiative, thrift and industry, no overstrained consideration for property interests and the right of one to do as he pleases with his own should stand in the way of just reparation for advantage taken of the people in a time of national stress, nor of drastic measures to prevent the continuation of extortion and profiteering, which is no more than a wholesale type of usury and as logically subject to restraint and punishment.

The Length of Boiler Seams

ON PAGE 23 of *Power* of July 1 we invited discussion on the safe limit of length in the longitudinal seam of a boiler. We have received some comments, but we want more.

Massachusetts will not allow a continuous longitudinal joint over twelve feet in length—whether it be of the butt-strapped or the lap variety—upon a horizontal return-tubular, vertical-tubular or locomotive-type boiler.

The Boiler Code of the American Society of Mechanical Engineers simply forbids the use of a course over twelve feet in length on horizontal return-tubular boilers with lap joints. With a butt-strapped joint a course of any length may be used provided specimens cut from the sheet parallel with the circumferential seams meet the standards prescribed in the specifications of the Code for boiler-plate steel.

This is one of the main points of difference between the two codes, and it is difficult to see why there should be any difference in this particular.

Does a boiler require the stiffening effect of the roundabout seams?

Does it require this as much with a butt-strapped joint as with a lap joint?

Is the long joint dangerous only when the sheet comes in contact with the fire as in the horizontal return-tubular boiler, and is this the reason that vertical-tubular and locomotive-type boilers are exempted in one code? If they are dangerous in the unexposed shells of fire-tube boilers, why are they not equally so in the drums of water-tube boilers?

Why does Massachusetts limit the length upon the three types, horizontal, vertical and locomotive, and the A. S. M. E. Code only upon one, the horizontal?

Why does the A. S. M. E. Code allow an unlimited length of course with a butt-strapped joint and restrict it with a lap joint?

Our thought in inviting discussion upon this subject is that it is after all an engineering question which ought to be decided definitely and positively one way or another if the best knowledge and experience and thought of the designers, builders, inspectors and users

of boilers were available. There is no doubt that the makers of the Massachusetts Rules and the A. S. M. E. Code want to be safe, but neither wants to be arbitrary or unnecessarily restrictive. When they both get the best that can be made, their codes will be alike and in that respect alone will be better for the man who manufactures the boiler as well as for the man who uses it.

Have you had any experience with boilers with long courses? Have you any ideas about them? What would you say about them if you were a member of the Massachusetts Board of Boiler Rules or of the A. S. M. E. Committee on Boiler Code and had to express an opinion? Which code is nearer right and why?

The Bonus System Successful at Denver Plant

IN MODERN power-plant management most engineers see in bonus systems a source of appreciable economies and labor contentment, yet to get these presents more obstacles than any other feature of management, operation and design. The human factor is always the most uncertain. Call together the heads of nearly every mill, factory or works and it will be agreed by all that bonus payment for the power-house men is highly desirable. But ask "How are we to apply it to our particular conditions?" The successful solution usually comes only after long consideration and many trials—all worth while. Those who have stuck to the problem and who have had many discouraging experiences are its strongest advocates. One never becomes so discouraged that he thinks there is not considerable to be gained by the application of the right system to his plant.

Readers likely remember that Dr. D. S. Jacobus, in his paper, "Methods of Increasing Boiler-Room Efficiency," an abstract of which was published in *Power* of July 15, referred to the bonus system as applied by Edward N. Trump, vice president of the Solvay Process Company. Mr. Trump's experience has made him an enthusiastic supporter of the bonus plan for power-plant men. He has made it work successfully in his great plant. Perhaps one of the most noteworthy examples of what a bonus system can do in a power plant is that of the Denver Gas and Electric Company, explained fully elsewhere in this issue.

This plant is, as its name implies, a central station; it is of average size and equipment. In the year that the bonus system now used has been applied, $150,000 has been saved on unit plant costs. The engineers have worked out a table giving the bonus to be paid for various coal consumptions per kilowatt-hour. This figure is now down to 2.47 pounds, and the total monthly bonus paid to the plant employees, who share alike, is $932. The shifts are now eight instead of twelve hours, and the number of employees has been cut from fifty-five to twenty-five. The men now get two weeks vacation with pay. The reduction in the number of men is in part because of more modern and larger equipment.

Bonuses at Denver are so arranged that the men share alike, so long as each has conformed to the bonus rules, which are given in the article and are worth the study of every engineer and manager. So far the bonus per man amounts to thirty-five dollars per month above the regular salary, ninety per cent. of which is paid monthly, though not on payday, the balance retained and paid semi-annually. Now when men have dropped into their hands as though out of the sky, such an amount, or amounts in proportion to saving effected, it becomes one of the most satisfactory kinds of welfare work employers can provide.

It should be noted that at Denver no special competition is fomented between watches. The amount each receives at the end of the month depends upon the combined efforts of all.

The Federation of Refrigerating Societies

THE foremost societies of the refrigerating industry have federated, forming a parent body known as the American Association of Ice and Refrigeration. It is composed of eleven, possibly more, organizations. The purpose of the consolidation is best set forth in the words of Frank A. Horne, president of the American Association of Refrigeration, who conceived the idea and is father of the movement. Mr. Horne said:

> During the reconstruction period there will be increasing necessity for joint activity and unified strength in confronting the problems of the future. It is evident to all that under the present arrangement there is much duplication of effort, loss of influence and power because of division, lack of breadth because of intensive specialization, loss of information by reason of separation, and waste of time and money in the separation of executive forces. This is no plea for a merger or a consolidation of forces, but for a better and more efficient federation of existing agencies and those that may be organized in the future.

The parent body, as this association will be called, is the medium of contact with international, national and state laws, organizations and functions. It will conduct statistical, educational, publicity and legislative development for the industry.

Certainly, refrigeration is one industry that needs the activity of such an organization. There is too much to be done to leave the work to be pursued in rather disjointed fashion. This organization will be to the refrigeration industry what the National Electric Light Association is to the electric public utilities. Rightly organized and guided, it can be made a clearing house for all essential information, technical, commercial and legal, relative to refrigeration, ice making and cold storage. Through it, with the influence it can be made to wield, the industry should be more successful than now in getting the governmental departments to assist in finding and serving the many data now needed by the engineers in the industry.

Reliability and economy are the real measures of the value of a power plant and its engineers. A poor plant with a good engineer is blessed; but a good plant in poor hands is doubly cursed.

Many a man who knows there is room at the top sits down and waits for the elevator.

Any kind of success worth having never arrives unexpectedly.

It is not knowledge but the application of it that is valuable.

Correspondence

Unreliable Safety Attachments

Just as the spring-loaded safety valve is the most dependable device for guarding against boiler explosions from overpressure, so is the automatic engine stop the best device for guarding against flywheel explosions from overspeed. The truth of this has been demonstrated time and again in the experience of engineers handling engines equipped with belt-driven governors.

An example of how little dependence can be placed on ordinary attachments for preventing inaction of the safety cams of a Corliss engine, in the event of the governor belt breaking, was found in a mill where the engine flywheels had been insured against accident.

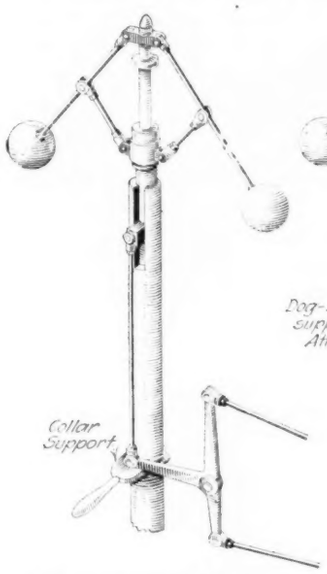


FIG. 1. DANGEROUS GOVERNOR-STOP COLLAR

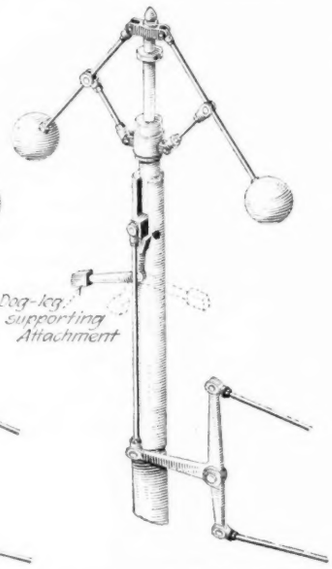


FIG. 2. A REASONABLY SAFE GOVERNOR STOP

In the original design of the governor on one of the insured engines, the contrivance for holding the governor balls at a starting plane when the engine was standing idle consisted of a brass collar with a projecting shelf and handle, encircling the governor standard, or supporting column, as shown in Fig. 1. It was presumed that after starting the engine the operator would turn the collar so that in the event of the governor belt breaking, the attached shelf would not keep the balls from dropping to the plane of safety, and that when shutting down he would shift it back again so as to catch the descending mechanism.

But there was about this device an obvious element of uncertainty that made it objectionable to the underwriters, so they ordered it taken off and the dog-leg attachment shown in Fig. 2 put in its place. The use of this is evident. When shutting down, the operator holds the dog-leg upright until the rectangular stud projecting from the governor sleeve rests upon it and thus secures it; then, when the engine is started and the governor balls rise, thus releasing the dog-leg, the latter promptly swings of its own overbalance, to the position indicated by the dotted lines.

But notwithstanding the automatic feature of this scheme, the personal element was almost as potent a source of danger as before. The engines were located in different parts of the mill, which occupied a city block, and were distantly separated from one another; the engine with the altered safety mechanism being kept in reserve. One night the bolts of a flange coupling that joined one of the main engine drives to the corresponding lineshafts were sheared off. This necessitated starting up the reserve engine, which transmitted its power to the system of shafting at the farther end. The main engine ran with a boiler pressure of 90 lb., but the reserve engine, being smaller, required 110 lb. The engineer speeded up the reserve engine with the boiler pressure still at 90 lb., but when the lineshaft load was thrown on by the closing of a friction clutch, the speed diminished until the safety cams intervened to stop the engine altogether. To keep the mill going while the fireman was raising the pressure to the necessary 110 lb., the engineer concluded to tie the dog-leg in the upright position with a piece of cord; standing by in the meantime and cutting the device loose when the pressure was high enough to keep the governor balls at the normal running plane.

Considering the circumstances, there was nothing censurable in this so far as the engineer was concerned. However, it afforded a pernicious object lesson to the boss of the mill hands, who was watching the proceedings. This person had formerly caused the engineer much annoyance by his habit of surreptitiously shifting the supporting collar around to the nonrunning position, his impression of the device being that it was a contraption put there simply to keep the engine speeded up. The dog-leg attachment presumably held him safe in this regard until he saw how easily its automatic feature could be nullified. At any rate when the engineer was making his periodical round of the plant an hour or so later, he found the dog-leg tied snugly to the governor post with its business end up. Subsequent events showed that his vigilance was timely. About half an hour later the worn-out lacing of the governor belt broke.

A. J. DIXON.

St. Louis, Mo.

Handling Superheaters During the Starting-Up Period

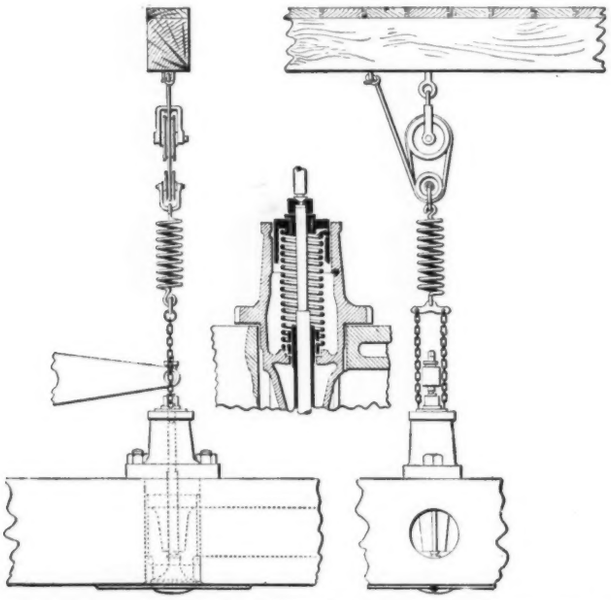
A difference of opinion arose recently in a group of engineers with regard to the handling of superheaters during the starting-up period. Some maintained that the superheater had to be—or at least ought to be—full of water at this time, while others said that boilers were always—or at least usually—started up without paying any attention to the superheater.

Will not the readers of *Power* help us to get at the facts by telling what their own practice is—and why?

New York City. F. L. RICHARDS.

Breaking of Diesel-Engine Valve Springs

With certain makes of vertical Diesel engines considerable trouble is caused by the breaking of the suction- and exhaust-valve springs. Since it is impossible to operate the engine with a spring broken, such an accident entails the cutting out of this particular engine.



MAKESHIFT TO OVERCOME BROKEN-SPRING TROUBLE

This is a source of much criticism in some plants where the service is dependent entirely upon a single Diesel-engine unit.

In an industrial plant containing a single 325-hp. vertical Diesel, this trouble was solved in an unusual and clever manner. Directly above each valve an eye-bolt was placed in the ceiling. The valve dashpot piston or cap was drilled and tapped in two places and two small eye-bolts were inserted with locknuts on the inner side of the cap. If a spring broke, a spring with two hook chains was connected to the cap in the manner shown in the sketch, and a small tackle-block connected the other end of the spring to the ceiling eye-bolt. The proper tension could then be given the spring. In this way the valve continued to function until the engine could be shut down after working hours. Such a device can be fitted to any engine of either horizontal or vertical type.

E. E. SNOW.

Philadelphia, Penn.

Ventilating Horizontal-Shaft Waterwheel Driven Alternators

Our metallurgical plants are supplied with power from an adjoining hydro-electric plant in which there are seven 5000-volt alternators having a total capacity of 15,000 kv.-a. The alternators are of the horizontal-shaft type, not adapted to artificial ventilation as is the modern steam-turbine driven machine with a different form of housing.

The atmosphere of the power plant becomes heavy with smoke and dust from the metallurgical plant, and as a result the generators get in very bad condition and require frequent cleaning. We wish to install an artificial ventilating system so as to keep the air clean in the power plant. By doing so the machine would operate satisfactorily. We do not know of any such installations in our own country and would appreciate very much hearing from some of *Power's* readers in America how they have handled such problems.

CHARLES A. KELLER, President,
Societi des Etablissements Keller et Leleux.
3 Rue Vignon, Paris, France.

Effect Economy by Changing the Hot-Water System

At a certain steam plant it was necessary to turn the exhaust steam through the heating system, thus robbing the hot-water supply heater of its share of exhaust steam. Consequently, live steam had to be used, and to reduce its use a ½-in. vacuum line was connected, as shown in Fig. 1, to the pipe connecting with the hot-water heater. When a vacuum was put on the heater, enough exhaust steam was pulled through it to raise the water up to 200 deg. F. The vacuum pump discharges to the feed-water heater.

At this same plant 8 lb. back pressure is carried on the exhaust-steam line of a hot-water heating system. At the end of the 1200-ft. 3-in. pipe line properly covered, but very few heat units were found at the hot-water heater to heat the circulating water. There is also above the 3-in. line a 5-in. line under 50-lb. pressure which is used only now and then. A connection was made from this line to the 3-in. line, which was then discarded. A thermostatic valve was connected in the vacuum-return line, as shown in Fig. 2.

After making this change the outgoing circulating water had a temperature of 188 deg. when the returns

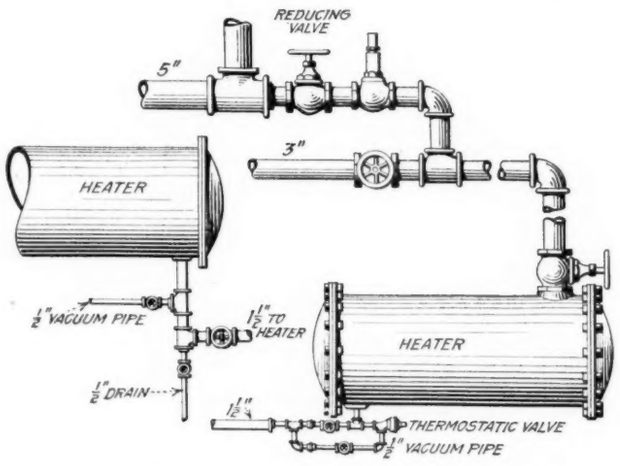


FIG. 1. VACUUM PIPE CONNECTION

FIG. 2. CHANGED PIPING ELIMINATED 3-IN. LINE

were passed through the thermostatic valve, and it was from 210 to 220 deg. when the vacuum pulled from the heater.

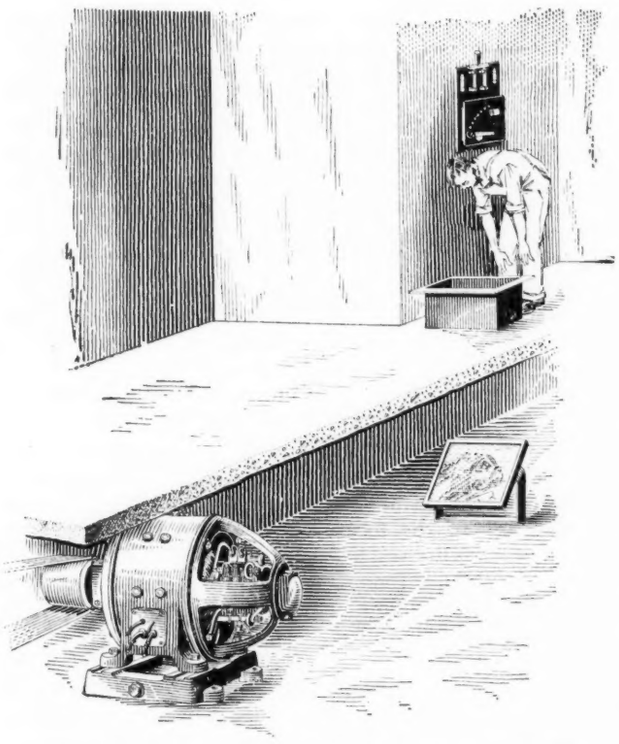
Less current was used by the motor, owing to the increased heat of the circulating water, and, being less dense, it had a tendency to circulate itself.

The recovery of 1200 ft. of 3-in. pipe, fittings and covering, practically new, less condensation in the 5-in. line, owing to increased circulation, and the saving of exhaust steam that could be used for other purposes, were the results of these changes, and these overbalance the fact that live steam is now used on the system.

Memphis, Tenn. J. A. LANDOLINA.

Mirror for Observing Motor

We have used a device similar to the periscope described on page 716 of the May 13 issue, in connection with a 50-hp. direct-current motor driving a rubber calender. There was not sufficient floor space to accommodate the motor, so we placed it in the cellar and connected it to the calender with a silent-chain drive. We placed the starter conveniently for the operator and cut a hole through the floor, placing a mirror at an angle so the motor could be seen from the starting panel. Thus, any excessive sparking or similar troubles can be detected at once.



OBSERVING A MOTOR BY MEANS OF A MIRROR

C. B. BRUSH.

New York City.

Installing Disconnecting Switches

In reading W. H. DeMuth's article in *Power*, page 740, May 13 issue, I get the impression that a circuit can be opened on a disconnecting switch with very little trouble. I believe a word of caution would be timely on this subject. The ordinary disconnecting switch, as supplied by the manufacturers of today, would be very unsafe to open under load conditions for circuits of 2300 volts and above.

I have before me a photograph of a lever switch opening a circuit under load with 13,000 volts on the line, and the arc rises eight to ten feet in the air. Indeed, an arc on a 600-volt circuit will easily reach four to six inches with only a few amperes load, especially if the circuit is inductive. Insulators for disconnecting switches are usually designed to stand from 2½ to 3 times the rated voltage. The distance, therefore, from the live parts to ground is very small as compared to the length of an arc that would occur when the switch was opened under load. A ground would be the result even if the line spacing was otherwise sufficient. Disconnecting switches are often called upon to open magnetizing current of power transformers and charging current of transmission lines. This should be considered the maximum of their current-rupturing qualities.

An operator who has the habit of hurriedly opening disconnecting switches without knowing the current that they are carrying will have plenty of time afterward to gather his thoughts while new switches are being installed or perhaps a new station built.

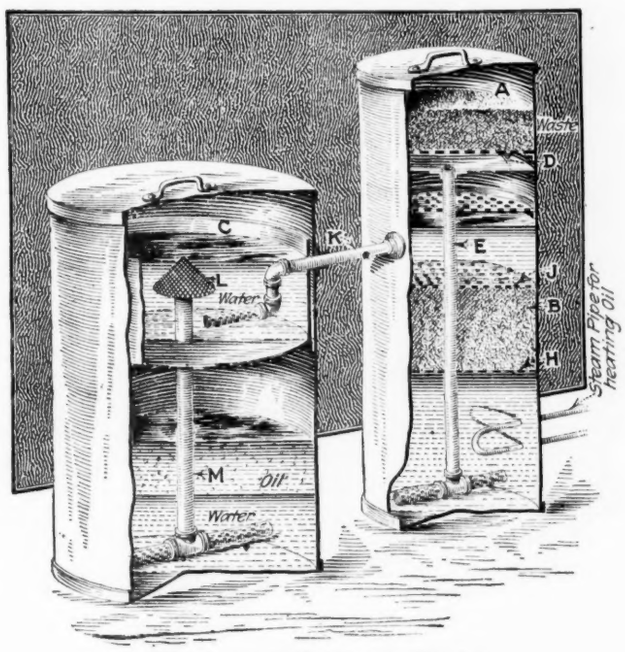
Milwaukee, Wis. H. D. MATTHEWS.

An Efficient Oil Filter

In a plant where I was employed there was a galvanized filter of the construction shown in the illustration. It cost the tinner $5 to make. The tank *A* is 10 in. high and 4 in. in diameter, tank *B* is 28 in. high, and tank *C*, which contains a wire-gauze strainer, is 14 in. in diameter and 8 in. high.

This filter meets the requirements of three generators and one engine, all being equipped with oil cups. The oil to be filtered is placed in the tank *A*. It then passes through a bed of waste that is supported by a perforated guard *D* and drains into the pipe *E* leading to the bottom of the tank *B*. The bottom of the pipe is T-shaped, the horizontal pipe being perforated to allow the oil to escape in small drops and filter up through the water contained in the tank below the lower layer of waste.

This serves to cleanse the oil, a considerable proportion of the gritty material falling to the bottom of the tank. The oil then passes through the waste bed that is secured between the lower and upper guards *H* and *J*. It is then conveyed by the pipe *K* from the bottom of the pan in the tank *C*, where it is again washed by rising through water. After reaching the surface of the water, the oil passes through a wire-gauze strainer *L* attached to a vertical pipe *M* leading to the bottom of tank. There it is again washed, finally rising to the surface of the water, when it is ready to be drawn off for use in the oil cups.



SECTION THROUGH OIL FILTER

J. C. KAHL.

Columbus, Ohio.

Maximum Length of a Longitudinal Joint in a Boiler

I have read the editorial entitled, "What Should Be the Maximum Length of a Longitudinal Joint in a Boiler?" and I can see no reason whatever for limiting the length of a barrel on account of any type of joint. If a barrel ten or twelve feet long is safe, it would be just as safe, from a theoretical standpoint, to make it one hundred feet long.

I do see some reason for restricting lap joints, but the reasons are all inherent in the action of the joint, regardless of the length of the barrel sheet. From a safety standpoint lap joints should be eliminated entirely and the test specimen for the material in the barrel should have its lengthwise dimension in line with the circumference of the barrel. In other words, if the longitudinal dimension on the sheet is laid circumferentially around the boiler, the test specimen should be taken longitudinally from the sheet. If, on the other hand, the lengthwise dimension of the sheet is parallel with the center line of boiler, the test specimen should be taken at right angles to the lengthwise dimension of the sheet

W. F. KIESEL, JR.

Altoona, Penn.

Experience with Automatic Indirect Heating System

I once took charge of an automatic, indirect, double-duct heating system, having had but little previous experience in similar operation. In my opinion this kind of heating system is an ideal one to heat and ventilate a building, especially a school. The air remains uniformly sweet and at a steady temperature, it is quick to heat in the morning and may be quickly regulated to follow sudden changes of weather.

To obtain such results, however, the operator must be sure that the air valves of the stacks are working properly. Mine are all supplemented with petcocks which are left partly open, those inside of the ducts thus helping to humidify the air, no special provision being made to that end.

The main thermostats at the reheated- and tempered-air chambers must be watched and also such rooms north and south of the building, from which a general idea can be had of the temperature of the remaining parts that are not of easy access.

The fans should never be started until the stacks are thoroughly heated and the air compressor, actuating the motors, is in full operation; also not before the main thermostats are set for quick heating. My system is divided into two independent parts, north and south. Each part has one high-speed engine and three thermostats: One, called the outside one, actuated by the atmospheric temperature, opens steam to the top tier at 36 deg. F. or below; one for tempered air, which I set at about 36 deg. F. for north and 32 deg. F. for south; and the last one on the reheated air, which I set for 100 or 120 deg. F. in cold weather. These temperatures must be reduced as the day becomes warmer. Here is where the guesswork comes in and keeps the man watching the results of the resetting of the main thermostats.

Do not allow opening of doors or windows to the outside. Be sure of this; it is hard to believe no fresh air can thus be obtained. Release a piece of paper at the opening and, if the system is in operation, the paper will fly out, not in, as some would expect it to do. This error not only is very wasteful of coal but will impair the heat regulation through the building.

In systems exhausting directly on the roof, the dampers of the exhausted ducts must be closed when shutting down the plant and opened when restarting. Systems exhausting in a garret, hence to the atmosphere, have the advantage of permitting recirculation of the same air at will when the building is vacant, thus saving coal. Sometimes I found that open exhaust dampers during the night allowed cold back draft into the room. This occurs in the daytime when the plant is in operation, and then if the thermostat happens to be installed in the foul-air duct, it remains cold and the room will become greatly overheated. This is as much an offense in a school as underheating.

When a room becomes underheated or overheated, do not do as I first did—make a bee line for the thermostat—but see what is the cause. It may be that the duct dampers controlling the air volume for that room have shifted through vibration, that the regulating motor dampers are stuck or that the rubber diaphragm of the motor is leaking, thermostat passages obstructed or that the thermostat has been tampered with by someone having a key. I overcome this by keeping tab of the figures at which I left the instrument set. Underheating may be due to temperatures too low in plenum rooms, air compressor inactive, steam back-pressure too low, engines not at proper speed, broken panes in windows or wind impinging against windows, etc.

One of the few drawbacks of this system is shown in mild weather when the steam consumption cannot be reduced to less than what it takes to keep the engines to proper speed, when the excess back pressure forces the back-pressure valve and exhausts in the atmosphere. In such a case do not be tempted to reduce the engine speed. Do not waste time trying to keep the thermostat indicator figure to correspond exactly with the thermometer, but use such a figure as a datum to go by. The instrument might have to be set at 64 deg. F. to obtain a 68-deg. F. temperature in the room; record such a figure near-by on the wall, or in a book. Do not allow anything to be hung on or near the thermostat.

I would deem a system ideal if designed so that the incoming air is filtered and automatically moistened; when both the reheated and tempered air is mixed long before it reaches its destination; when all the ducts are air-tight and thoroughly insulated, and when it is possible to recirculate the same air when the building is vacant and in need of heat to prevent freezing.

A. FISK.

Jamaica, N. Y.

Concrete Boiler Settings

On page 934 of the June 17 issue of *Power*, I notice in the first sentence of the article on concrete settings of boilers, that the engineers of Robert Gair Co. went so far as to use cinder concrete for boiler settings and used no firebrick lining. Have you any data on the results? This seems so absolutely contrary to all reason that I am very much interested in knowing how it came out.

E. MARSHALL,
Electrical Engineer,
Great Northern Railroad.

St. Paul, Minn.

Inquiries of General Interest

Brine Solution Too Strong—The valves and rods and part of the cylinders of our brine pump lately gather considerable salt crystals. What is the cause? M. C.

This is usually an indication of having too strong brine.

Regulating Forced Draft of Vertical Boilers—We have three 150-hp. vertical fire-tube boilers, operated by forced draft from a fan blower connected by a branch pipe with shutoff to each boiler ashpit, and in addition there is a damper in the main pipe from the blower that is controlled by a regulator. Would it not be better to leave these dampers wide open and regulate the draft by means of the uptake damper? F. A. C.

The present arrangement is better than regulation of draft by the uptake damper, because any time the latter chanced to be partly or entirely closed, the blower would build up excessive pressure in the furnace, causing hot gases and ashes to be blown out of the fire-doors.

Motor Wire Not All the Same Size—We have a 20-hp. induction motor operating on a 230-volt three-phase 60-cycle circuit. The motor is connected to the starting device with two No. 3 and one No. 0 conductor. What effect if any has the difference in size of conductors on the operation of the motor? W. P. B.

It is doubtful if the machine in question is a three-phase motor, but more likely a 3-wire two-phase machine, although the former may be correct. In 3-wire two-phase systems the cross-section of the center wire is usually made 1.414 times that of one of the outside wires; this to take care of the current in the center leg of the system, which is 1.414 times that in one of the outside legs. However, if your machine is a three-phase motor, the one larger wire will have little effect on the operation of the motor. It would have a tendency to unbalance the voltage of the three phases, but this will be so slight as to be practically negligible.

Glass Gage for Pump Air Chamber—What should be the height of a glass gage on an air chamber of a pump that operates against a gage pressure of 105 lb. per sq.in.? J. W. C.

With a discharge pressure of 105 lb. gage or about 120 lb. per sq.in. absolute, the air contained in the air chamber at atmospheric pressure would be compressed to about $\frac{15}{120}$ or $\frac{1}{8}$ of its original volume. If the air chamber is a vertical cylinder, the water level would be raised to within about $\frac{1}{8}$ the height measured from the top. With a pear-shaped air chamber having the lower or conical portion about 3 times as long as the diameter of the hemispherical top, the water level would rise to within about $\frac{1}{8}$ of the diameter below the top of the air chamber. For indicating the conditions, it is well to have the glass gage connections so arranged as to show any standing of the water level from the top down to about one-half the total depth of the air chamber.

Compound-Wound Motor Reverses When Starting—What would cause a compound-wound motor to reverse its direction of rotation upon reaching the third point of the starting rheostat? What would cause the same motor to run within normal speed limits at one starting and accelerate to a dangerous speed at another starting? H. W. C.

The trouble is caused by the series- and shunt-field windings being connected in opposition. The starting resistance was cut out at a rate that allowed the armature current to build up to a value, when the third point of the starter was reached, that made the ampere-turns of the series winding greater than the shunt-winding ampere-turns. This reversed the polarity of the polepieces and consequently reversed the direction of the motor. In general, if a compound-wound motor with its field winding connected in opposition is starting under light load and is accelerated slowly, it will come up to normal speed without giving any evidence of anything being wrong. However, if an attempt is made to accelerate the same motor rapidly, it will reverse before the starting resistance is cut out, as explained in the foregoing, or it may run at a dangerous speed due to the demagnetizing effect of the series-field winding.

Discharge Through Part Open Globe Valve—A 2-in. disk globe valve in a feed line has a valve stem with six screw threads to the inch. When the valve is open one-eighth of a turn with 170 lb. pressure on the boiler and 178 lb. pressure on the feed line, how much water should pass through the valve in an hour? J. W. C.

The velocity of water discharged through the valve from a pressure of 178 to 170 lb. per sq.in. would be the same as for a difference of head of $(178 - 170) \div 0.433 = 18.48$ ft., and for that head the theoretical velocity would be $\sqrt{2gh} = \sqrt{2 \times 32.16 \times 18.48} = 34.48$ ft. per sec., or $34.48 \times 12 \times 60 \times 60 = 1{,}489{,}536$ in. per hour. If backlash of the screw is taken up, the lift of the valve for one-eighth of a turn of the stem would be $\frac{1}{8}$ of $\frac{1}{6} = \frac{1}{48}$, or about 0.02 in., and for a valve seat with 2-in. diameter of aperture there would be an annular opening of $2 \times 3.1416 \times 0.02 = 0.126$ sq.in. The coefficient of discharge would be approximately 0.6, depending on the form and roughness of the valve, and the actual discharge would be about 0.6 $(1{,}489{,}536 \times 0.126) \div 231 = 487.5$ gal. of water per hour.

Horsepower of Pump—What is meant by the horsepower of a pump? H. P. R.

Five different values of horsepower of a pump must be distinguished: (1) The indicated horsepower of the steam end, obtained from indicator diagrams of the steam end in the same way as determining the indicated power of a reciprocating engine; (2) the brake horsepower, or power actually transmitted to the pump, and which in a direct-acting steam pump would consist of the indicated power of the steam end less the friction of parts essential to operation of the steam end; (3) the indicated horsepower of the water end, obtained from indicator diagrams taken from the water cylinder to determine the power transmitted by the water piston or plunger; (4) the water, or developed, horsepower to express the useful work done by the pump, based on the actual weight of water discharged and total height through which the water is elevated; (5) what is commonly recognized as the nominal horsepower, which is based on the weight of water that would be displaced per minute by the plunger or piston if there were no slippage, combined with the discharge pressure plus the lift measured from the water level in the suction well to the height of the discharge gage. Thus, if the plunger or piston displacement is 1000 gal. per minute, it would be assumed that the pump actually handled $1000 \times 8\frac{1}{3} = 8333$ lb. of water per minute; and if the discharge pressure indicated 40 lb. per sq.in. and the height of the gage was 16 ft. above the water level of the suction gage, the total lift would be considered as equivalent to (40 lb. $\times$ 2.3 ft. per lb.) + 16 ft. = 108 ft., making $8333 \times 108 \div 33{,}000 = 27.27$ nominal pump horsepower.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications.—Editor.]

Boiler-Water Treatment*

IF YOU cover a steam pipe with asbestos, magnesia or other heat-insulating material, you keep the heat in the steam; if you line or coat a boiler tube with scale or other heat-insulating material, you keep the heat out of the boiler water and send it to the stack. By lagging your pipes you save fuel easily. By lining your tubes with scale you waste it continuously and needlessly.

All natural waters contain more or less of this heat-insulating material, partly as suspended matter (clay, fine sand, insoluble forms of iron, aluminum, etc.), partly as dissolved matter, such as compounds of calcium, magnesium, sodium, potassium and other mineral salts.

Much of the suspended matter, as well as most of the dissolved matter, may form scale, but the suspended matter may generally be removed by filtration, which will be discussed later.

Dissolved Matter Which Forms Scale

Of the material commonly in solution in boiler waters, the bicarbonates and sulphates of calcium and magnesium are the most important scale formers. Natural waters containing in solution bicarbonate of calcium or magnesium or both exhibit what is called "temporary" or "carbonate" hardness; those containing dissolved calcium or magnesium sulphate or both possess "permanent" or "sulphate" hardness. In the case of the sulphate scale the temperature required to separate it is too high to make its removal by heating alone a practical means of treatment. In the case of water exhibiting carbonate or temporary hardness great improvement in its properties may be effected by the use of open heaters of the exhaust-steam type. As a rule sulphate scale is denser in structure with a higher heat-insulating value than carbonate scale, but the conditions of formation affect this considerably. Where a porous structure permits water to penetrate the scale, its heat-insulating effect is greatly reduced.

The Effect of Scale

In many respects the effect of an increasing deposit of scale on the passage of heat through the walls of a boiler tube is very similar to the effect on the passage of water through a tube of continually decreasing bore. In the case of the water tube, the only way to get a uniform volume of water through it in a given time, in spite of its diminishing bore, is continually to increase the pressure in the water; so in the case of a boiler tube covered with a dense scale the only way to maintain a constant flow of heat from the furnace to the boiler water is to increase the "heat pressure," so to speak; that is, to burn more fuel.

The most important effect of scale is due to the fact that in certain forms it is a wonderful heat insulator. Its chemical composition seems to have little to do with its heat-insulating power, the big question being the density or mechanical structure of the scale. A series of experiments by Professor Schmidt, of the University of Illinois, gave the results given in the table, showing decrease in heat-transfer efficiency of tubes coated with scale of different thickness and composition.

DECREASE IN HEAT-TRANSFER EFFICIENCY CAUSED BY SCALE

Character of Scale	Thickness, In.	Composition	Loss of Efficiency, Per Cent.
Hard	$\frac{1}{32}$	Mostly carbonate	9
Soft	$\frac{1}{32}$	Mostly carbonate	7
Hard	$\frac{1}{32}$	Mostly carbonate	8
Soft	$\frac{1}{16}$	Mostly carbonate	8
Hard	$\frac{1}{16}$	Mostly sulphate	9
Hard	$\frac{1}{16}$	Mostly sulphate	11
Soft	$\frac{1}{16}$	Mostly sulphate	10
Soft	$\frac{1}{16}$	Mostly carbonate	11
Soft	$\frac{1}{16}$	Mostly carbonate	12
Hard	$\frac{1}{16}$	Mostly carbonate	12
Soft	$\frac{1}{8}$	Mostly carbonate	15
Hard	$\frac{1}{8}$	Mostly sulphate	16

This expressed in dollars and cents means that with a deposit of $\frac{1}{8}$ in. of scale, 16c. of every dollar paid for coal is lost.

*From one of the bulletins distributed by the Fuel Administration and the Bureau of Mines.

The data just given must not be regarded, however, as indicating that the decrease in the heat-carrying capacity of scale-covered tubes can always be calculated with the accuracy that these figures would indicate. The important facts are, though, that the loss is easily prevented and that the advantages of soft water abundantly justify all expenditure necessary to secure it.

Means of Removing "Scale Formers" from Water

The methods employed in softening water may be divided into two main classes, those in which the scale-forming property is removed before the water enters the boiler, and those in which the softening is effected within the boiler itself by means of so-called "boiler compounds."

As to which one of the two classes of methods should be employed in any particular case would depend on the size of the plant and on the character of the water to be softened. In the case of waters of abnormal composition it would frequently be impossible to produce a satisfactory water by either method and a new water supply would be necessary.

It cannot be too strongly emphasized that this question of water treatment is one in which the employment of competent chemical and engineering knowledge is both absolutely necessary and highly profitable, and it would be far wiser to omit all forms of water treatment (involving the use of chemicals) rather than to undertake such without knowing accurately the composition of the water and of the material used to soften it. It is most important to remember that the quality of the water, even when secured from the same source, varies widely from time to time. These variations are not only seasonal and monthly, but daily and even hourly. A condition of excessive concentration of the water after a protracted drought may be changed within an hour to a correspondingly excessive dilution by a summer storm. The result would be to decrease enormously the percentage of dissolved matter and to increase, probably to a much greater degree, the amount of suspended matter.

As a consequence a prescribed treatment of the water based on its analysis at any particular time might not lead to satisfactory results if applied at some other period.

As an instance of the serious danger of an unintelligent "dosing" of boiler waters may be cited the results of a long series of investigations which have, apparently, shown that carbonate of soda in solution produces brittleness in boiler steel. Carbonate of soda (soda ash) is used in most water-treating processes and its unintelligent use may readily lead to a very dangerous condition in a boiler.

When Boiler Compounds May Be Used

Boiler compounds afford a useful means of boiler-water treatment in plants whose size or value of output would not justify the use of a more expensive method. This would be true of a large percentage of the plants of the country.

In spite of a great variety of trade names a very large percentage of all boiler compounds consist most largely of carbonate of soda, to which caustic soda is sometimes added, and occasionally phosphate of soda. Starchy materials and those containing tannin are frequent ingredients. The supposed effect of these last two materials is to coat the particles of precipitated incrusting material and prevent its cohesion into compact scale.

The chief disadvantage (assuming that they are used intelligently) is the necessity of frequently blowing down the boiler to prevent the accumulation of "sludge" and of alkaline (sodium) salts in the water, both of which cause foaming. Furthermore, this blowing down must be supplemented by washing out, and occasionally closing down the boiler to complete the removal of the sludge and of the boiler compound itself

Whenever competent supervision of boiler-water treatment is available within the plant organization, it is preferable to soften the water before it enters the boiler, and this must be done when the percentage of scale-forming ingredients is high.

By Treating the Water Before It Enters the Boiler—The removal of scale-forming components from water by chemical means, whether before or after entering the boiler, is accomplished by converting the calcium and magnesium compounds into practically insoluble forms, causing them to separate from the water and allowing the material to be removed by blowing down, filtering or sometimes by settling. Lime and soda ash are generally used for this purpose when the softening occurs before the water enters the boiler. The lime combines with the carbon dioxide which held the calcium and magnesium carbonates in solution; these are no longer soluble in the water after removing the carbon dioxide, and therefore separate from it. In a similar way the sulphate scale is removed by its conversion to insoluble carbonate by the soda ash.

The Lime-Soda Process—There is in current use in power plants practically only one lime-soda process, of which there are two varieties differing chiefly in the temperature of the water when treated. In all essential respects the two varieties are similar. The treatment consists of adding to the "raw" water softening agents in carefully controlled amount (which must agree with the composition of the water), mixing these thoroughly within the water, and permitting sufficient time to elapse for the separation of the "sludge" before the water is fed to the boiler.

In the case of the "hot-continuous" process this separation is effected more rapidly, which permits of less storage capacity than in the case of in the cold-continuous. In all cases, though, it is of the utmost importance to provide sufficient storage space to allow the sludge to be completely deposited before the water is fed to the boiler; otherwise the partly completed softening process will be completed within the heater, and the purpose of the treatment will be largely defeated. Another advantage of the hot process is that it expels the air from the water and so reduces the corrosion.

The Zeolite Process—This is entirely unlike the processes already described and (unlike them) gives a water of zero hardness. The softening agent is an artificial material composed largely of sodium compounds, which are exchanged for the incrusting (scale-forming) material of the water; that is, the water dissolves sodium compounds from the softener and replaces it by the calcium and magnesium which had caused the hardness of the water. The hard water simply flows over the permutit packed in a cylinder or is forced up through it and flows from it with all scale-forming material removed. After a time the softener must be regenerated by allowing a solution of salt to flow over it, restoring its original composition and activity. The "permutit" process is a well-known efficient variety of the zeolite treatment.

Advantages and Disadvantages of Zeolite Process

The construction and operation of this softening equipment is extremely simple. On the other hand, in the case of water of a high degree of temporary or carbonate hardness there is a correspondingly large amount of sodium salts introduced into the water so that foaming is liable to occur (as is liable to occur when softening water of a similar composition by means of boiler compounds). In such cases the following modified form of the zeolite process is used.

In this an intermittent or continuous tank equipment, as described already under the lime-soda process, is connected through a filter to a zeolite softener. Only lime is used in the tank, the soda compound being secured from the zeolite. The filter is placed between the tank and the zeolite softener to avoid any sludge coating the permutit particles and so impair its efficiency.

No process of water softening is satisfactory unless the amount of suspended matter is reduced to a minimum. In the case of very finely divided matter this may be done by adding so-called coagulants—alum, for example—but these should be used with extreme caution and always under expert direction. Ordinarily, though, such suspended matter is removed by filters, of which the sand filter with a down flow of the water is the most satisfactory type. They are not expensive either in original or maintenance costs.

The purpose of the methods described is to prevent the formation of scale. There is another class of water-treating material used largely to remove scale already formed and to some extent prevent the formation of new scale. Graphite and kerosene are most often used for these purposes. Their action seems entirely mechanical.

Opinions as to the desirability of their use vary from enthusiastic commendation to absolute condemnation, though their use seems generally approved by practical men. Neither should be used, however, in boilers in which there is already a heavy deposit of scale, as the loosening of this and its accumulation in the bottom of the boiler is likely to lead to blistered and bagged boiler metal.

Some Examples of Economies Effected by Softening Water

There is a very direct relation between softening water and saving fuel; the following are a few cases reported of such economies.

1. A marble company reports a saving of 21 per cent. of fuel by softening its boiler water.

2. A crucible steel company, by substituting soft for hard water, effected a saving of 3600 tons of coal per annum, which based on current prices would be valued at about $22,000.

3. The Chicago & Northwestern Railroad Co., comparing its operating expenses in 1902-3 before and after softening its water supply reported a saving of $75,000 per annum. This saving was effected at a period when coal cost probably less than one-half the prices charged to-day (1918).

4. In addition to these, other cases have been reported in which the profits resulting directly from the substitution of soft for hard water have been reported as varying from 32 per cent. on an investment of $7200 to 71 per cent. on an investment of $7000. These profits resulted largely from the elimination or reduction of operating costs, such as cleaning heaters, piping, and economizers, cost of cleaning instruments, interest, and depreciation of spare or idle boiler, etc.

5. Furthermore, it has been estimated that the use of hard water in a great number of the locomotive boilers of the country involves the consumption of 15,000,000 tons of coal more than would be needed were soft water only used.

6. A steel company whose annual output is 50,000 tons reports a saving of 200 lb. of coal per ton of steel resulting from the softening of its boiler water.

A Suggested Formula for Rating Kerosene Engines*

By D. L. Arnold

Among the various companies manufacturing kerosene engines there seems to be no uniform standard of rating in use, and as a result engines of the same bore, stroke and speed—or in other words, of the same piston displacement per minute—are given different ratings by almost as many manufacturers. For instance, one buys an engine of 4 hp. that will actually develop 6.5 hp.; someone else buys one also rated 4 hp., but it will develop only 5 hp., and it will in all probability have a different piston displacement per minute. Apparently this means nothing as far as the customer is concerned, for in each case he receives more horsepower than he believed he was purchasing. A great difficulty does, however, arise when these engines are judged by the amount of maximum work which they will perform in a given length of time, not on brake tests but on users' equipment, and the result is that the purchaser of the smaller engine is greatly dissatisfied, despite the fact that his engine will develop a 25 per cent. overload.

The foregoing is only a sample case of the inconsistency that has resulted in many bills now being introduced, or about to be introduced, in state legislatures, specifying how an engine shall be rated. If these bills should all pass it might be that each state would require a different rating, and thus the manufacturers would be obliged to furnish a different name-plate in each state. It would therefore seem advisable for the manufacturers to get together and

*Presented at the Spring Meeting, Detroit, Mich., June, 1919, of the American Society of Mechanical Engineers.

adopt a standard rating for kerosene engines; and this work would be greatly facilitated if the engineers of this society and of the Society of Automotive Engineers would coöperate and adopt a standard rating for this type of power plant.

FORMULAS NOW IN USE FOR FOUR-STROKE-CYCLE ENGINES

D = Diameter of piston, in. L = Length of stroke, in.
n = Number of cylinders. N = Number of revolutions per minute.

No.	Authority	Formula
1	N.A.C.C.* or A.L.A.M.	$\frac{D^2n}{2.5}$ (at 1000 ft. per min.)
2	E. P. Roberts	$\frac{D^2LNn}{18{,}000}$
3	French Automobile Club	$0.45D^2n$ (at 985 ft. per min.)
4	Royal Automobile Club, British	$0.405\ D^2n$
5	Royal Automobile Club, Swedish	$\frac{D^2L\,Nn}{15{,}240}$
6	Prof. H. L. Collanders	$\frac{0.565\ D\ (D-1)n}{D^{2.6}L^{0.76}n}$
7	T. Thornycrofts	$\frac{}{2700}$
8	M. Faroux	$0.121\ D^2\ {}^4L^{0.8}$
9	M. Arnon	$0.1\ D^2n$
10	E. W. Roberts †	$\frac{D^2L\,Nn}{X}$

* Vol. I, p. 30, S.A.E. Standards Data Sheets.
† Gas Engine Handbook, p. 131. X is a factor varying with the fuel and cycle. For 4-cycle engines X equals 16,000 for natural gas and 14,000 for gasoline.

If standard rating is to be of service, it must give equal protection to the manufacturer and the customer, and any formula which is obtained must therefore be based upon practice covering a sufficient period of time. Before taking up the proposed formula, however, the writer wishes to review some of the formulas that are in use today and which are listed in the table.

The A. L. A. M. formula[1] is based on the assumption that there is developed within the cylinder a mean effective pressure of 90 lb. per sq.in., that the engine operates with 75 per cent. mechanical efficiency, and that the piston speed is 1000 ft. per min. With ungoverned engines this formula is perhaps as good as any, but for engines operating with governors it is obvious that if a piston speed of other than 1000 ft. per min. is maintained, it will be necessary to make a correction to cover this point, in which event the formula is unwieldly and inconvenient.

An empirical formula[2] which is considered as very conservative practice when compared with the various ratings now used by engine manufacturers, is as follows: B.hp. = $0.00006042\ D^2LNn = V/13{,}000$. Before deriving this formula the writer compared the ratings of 115 engines manufactured by 61 companies and found them to vary from 8256 to 19,985 cu.in. per b.hp. Forty-six engines were rated using 11,000 cu.in. or less as 1 b.hp.; 29 used 11,000 to 12,000 cu.in.; 12 used 12,000 to 13,000 cu.in.; 10 used 13,000 to 14,000 cu.in. and 18 used above 14,000 cu.in.

It will thus be seen that 87 engines, or approximately 75 per cent., were rated as using less than 13,000 cu.in. per b.hp., and while this value may be more conservative than some manufacturers might wish to use, it gives a standard basis of comparison and allows the engine to develop a fair percentage of overload above its rating, since any engine should be able to develop as a maximum 1 b.hp. per 11,000 cu.in. piston displacement per minute when the engine is in good condition.

With reference to the rating of four-stroke-cycle engines, it would seem best for all concerned that this rating should be made the nearest whole horsepower to that determined by the standard formula, it being an easy matter to change the rated speed of the engine in order to accomplish the exact rating. In any event, however, the rated horsepower would not, if the foregoing condition is adhered to, vary more than plus or minus 0.5 hp.

In considering the internal-combustion-engine rating we must also consider the tractor rating as the internal-combustion engine forms its power unit and the tractor rating is therefore dependent upon the engine rating. The owner of a tractor is interested not only in the amount of power that can be delivered by the engine, but also in the amount that can be delivered to the drawbar at the different speeds. Here again, however, manufacturers have been inconsistent in the ratings they have made. The majority of manufacturers have followed the rule that drawbar horsepower should be considered as 50 per cent. of the rating of the power unit, and in actual practice covering many years of experience this seems to be a very conservative figure to use. It is true that the tractor will often develop greater drawbar horsepower, but when taking into consideration the wide range of conditions through which the tractor must work, such as changes of soil and class of work, a 50 per cent. rating for the drawbar pull seems on the whole to be the best value to use.

The following formulas are those which it would seem are best adapted to the rating of internal-combustion engines and tractors:

$$\textit{Rated engine horsepower} = \frac{0.7854\ D^2LNn}{13{,}000} \quad (1)$$

$$\textit{Drawbar horsepower} = \frac{\textit{Rated engine horsepower}}{2} \quad (2)$$

$$\textit{Drawbar pull, lb.}^{3} = \frac{375 \times \textit{rated drawbar horsepower}}{\textit{travel in miles per hour}} \quad (3)$$

$$\textit{Motor torque,}^{4}\ \textit{in.-lb.} = \frac{63{,}025.21 \times \textit{brake horsepower}}{N} \quad (4)$$

Practical work in experimental testing laboratories and on regular test floors has proved that four-stroke-cycle engines operating on kerosene will develop for periods of two hours or more 1 b.hp. per 11,000 cu.in. piston displacement per minute and a few engines have for short periods of time developed 1 b.hp. for every 9800 cu.in. piston displacement per minute. Therefore, making allowances for general wear, mishandling and improper adjustment, the formulas given will be seen to be conservative and well adapted for the rating of this type of engine.

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[1]Derivation of A.L.A.M. Formula:

Let HP_b = brake horsepower
HP_i = indicated horsepower
HP_r = rated horsepower
A = area of piston, sq.in.
D = diameter of piston, in.
E = mechanical efficiency (assumed at 0.75)
L = length of stroke, in.
n = number of cylinders
P = means effective pressure, lb. per sq.in. (assumed at 90 lb.)
V = piston displacement per minute, cu.in.
N = revolutions per minute
s = piston speed, ft. per min. (assumed at 1000)

$$HP_b = HP_i \times E = \frac{1}{4}\frac{PAsn}{33{,}000}E = \frac{90 \times 0.7854\ D^2 \times 1000 \times n \times 0.75}{4 \times 33{,}000}$$

$$= \frac{D^2n}{2.489}, \text{ or for practical purposes, } \frac{D^2n}{2.5}$$

Also, since $s = \frac{2LN}{12}$

$$HP_b = \frac{90 \times 0.7854\ D^2 \times 2LN \times n \times 0.75}{4 \times 33{,}000 \times 12} = \frac{D^2LNn}{14{,}939} = 0.00006693\ D^2LN$$

and substituting V for $0.7854\ D^2LNn$

$$HP_b = \frac{90 \times V \times 2 \times 0.75}{12 \times 33{,}000 \times 4} = \frac{V}{11{,}733}$$

[2]Derivation of Empirical Formula:

$$HP_r \text{ (recommended)} = \frac{0.7854\ D^2LNn}{13{,}000} = \frac{V}{13{,}000}$$

$$HP_r \text{ (transformed)} = \frac{D^2LN}{16.550^n} = 0.00006042\ D^2LNn$$

[3]Derivation of Drawbar Pull Formula:

Let F_d = drawbar pull, lb.
HP_d = drawbar horsepower
S = speed in miles per hour

Then $F_d = \frac{HP_d \times 33{,}000 \times 60}{5280 \times S} = \frac{375\ HP_d}{S}$

[4]Derivation of Motor Torque Formula:

Let HP_b = brake horsepower
l = length of brake arm, in.
W = lb. pull at end of arm
N = revolutions per minute
T = motor torque, in.-lb.

Then $HP_b = \frac{2\pi\ lnW}{33{,}000}$

$$T = \frac{HP_b \times 33{,}000 \times 12}{2\pi N}$$

$$= \frac{63{,}025.21 \times HP_b}{N}$$

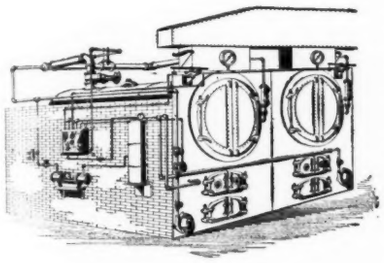
Condensed-Clipping Index of Equipment

Clip, paste on 3 x 5-in. cards and file as desired

Control, Oil Seal Combustion

Vapor Vacuum Heating Co., Otis Building, Philadelphia, Penn.

"Power," June 3, 1919

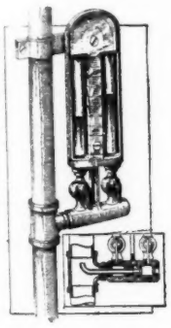


The system operates on the principle that the furnace of a boiler is the agent for determining the amount of draft to the chimney, and the quantity of air to be passed through the fuel bed to support combustion. When the steam pressure drops, the air applied to the furnace is increased. The position of the damper is changed in proportion to the quantity and pressure of gas generated in the furnace on account of the increase or decrease in the rate of combustion.

Indicator, Royer Flow

Sloan-Striker Co., Detroit, Mich.,

"Power," June 17, 1919



This instrument adopts the pitot tube with an inverted U-tube measuring the differential between the dynamic and static heads and indicating the flow in steam, gas or water or air lines. A chart is supplied with the instrument to assist in computing the quantity of flow. The scale is divided into tenths and may be calibrated into gallons per minute, cubic feet per minute, pounds per hour or any unit desired. In the case of gas or steam a second chart is used to correct the variations from the temperature or pressure at which the meter is expected to operate.

Pump, Weber, Subterranean

Weber Subterranean Pump Co., 50 East 42d St., New York City.

"Power," June 17, 1919

This pump is designed for lifting water from driven wells and operates with compressed air. It is of a displacement and internal exhaust type. Ball-check valves prevent water from falling back into the well. The intake chamber is from 4 to 10 ft. long, and the discharge pipe diameter increases as it approaches the ground level. The cage ball valves are made of bronze, the balls are hollow and are so balanced that the center of gravity is at the center of the valve.

Piston Ring, Blauvelt

F. N. DuBois & Co., 9th Ave. & 25th St., New York City.

"Power," May 20, 1919

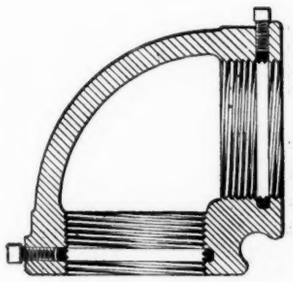
A piston ring designed for internal-combustion engines of the composite type is made up of a plurality of rings. The bull ring is grooved for an inner expansion ring, and two packing rings are mounted to encompass the carrier ring and the expansion ring. Each packing ring is beveled on its inner face against which the expansion ring bears, the bevel tending to move the two packing rings apart on the carrier ring. A single pin prevents the expansion and the two packing rings from turning, so that the joints of the rings cannot come together.

Fitting, Tight Joint

High Pressure Fitting and Valve Co., Inc., 72-74 Putnam St., Paterson, N. J.

"Power"

When using this fitting the pipe is screwed into it. The fitting is made with a lead joint or ring that extends slightly beyond the thread of the fitting. When the pipe is screwed into the fitting, it expands the lead packing, causing it to fill the threads. If the threads are not tight, one or more turns of the setscrews will crowd the lead around them, thus making the joint tight. The fitting is used for ordinary low-pressure work.

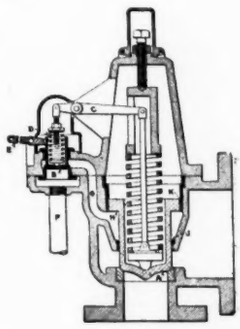


Valve, Full-Capacity Safety

Atwood & Morrill, Salem, Mass.

"Power," May 27, 1919

This valve consists of a main and a pilot valve. The main valve is set at somewhat higher pressure than the pilot valve, and the movement of the main valve has a direct cutting-off action on the pilot valve; thus the valve will open to full capacity where there is a continued increase of pressure, but it will not do this at the first pop. The cutting-off action of a lever actuated by the main valve acts on a pilot-valve spring, and an upward movement of the pilot valve allows a flow of steam through a passage and acts on an annular surface and thereby opens the main valve.

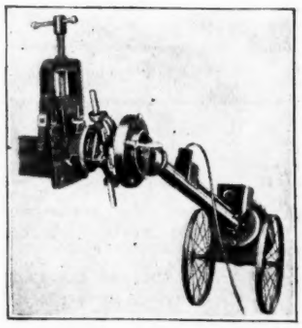


Drive, "Toledo," Power

The Toledo Pipe Threading Machine Co., Toledo, Ohio.

"Power"

The "Toledo" power drive is a new electrically driven device for operating hand pipe-threading and cutting tools. It is portable. The motors are 1½ hp. and furnished for the necessary type of current. Each outfit includes 25 ft. of flexible cable fitted with a single plug connection. It is started and stopped by a push-button switch. It has a two-speed transmission gearing, and the change from one speed to another is made by pulling out or pushing in a knob.

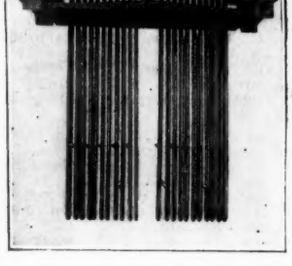


Superheater, Stationary Boiler

Locomotive Superheater Co., 30 Church St., New York City.

"Power," May 27, 1919

This superheater consists of two headers, one acting as a distributor for the saturated steam and the other as a superheated header for the collection of steam after it has been superheated. The headers are made of steel and are located outside of the hot gas path, usually outside the boiler setting proper. The tubes are bent and are connected to the headers by means of ball-and-socket joints with ground surfaces. The ball of the joint is forged on the end of the tube and fits into a ground seat in the header. The ball and seat are held in contact by means of clamps, bolts and washers. The superheater is built in units.



Patented Aug. 20, 1918

Amendments to New Jersey Boiler Code

At the meeting of the New Jersey Board of Boiler Rules, held at Newark, N. J., July 24, several amendments were incorporated in the New Jersey boiler code relating to new installations; a code was also adopted governing existing installations.

The factors of safety applying to old boilers are to be not less than the following: A factor of 4 for boilers not over 20 years old and 4¼ for boilers over 20 years old, provided in each case they have longitudinal joints of butt and double-strap construction.

For old lap-joint boilers the following factors were adopted: 4¼ for boilers not over 5 years old; 4½ for boilers over 5, but not over 10 years old; 4¾ for boilers over 10, but not over 15 years old; and 5 for boilers over 15, but not over 20 years old. The code of the board was ordered printed. Until copies are ready for distribution information may be obtained by addressing N. J. State Board of Boiler Rules, care of the Department of Labor, State House, Trenton, N. J.

Oscar Otto

Oscar Otto, general superintendent of the South Philadelphia Machine Works of the Westinghouse Electric & Manufacturing Co., died on Monday, June 30, as a result of injuries received in an automobile accident on the previous Friday morning.

Mr. Otto was born in Manitowoc, Wis., Jan. 2, 1859. He finished an apprenticeship course as a machinist in the Manitowoc shops of the Chicago & Northwestern R.R. and after serving several years at various places in the State of Wisconsin, he accepted a position with the Northern Pacific Railroad Co. at Tacoma, Wash., going from there to the Oregon Short Line at Salt Lake City.

Prior to becoming general superintendent of the Westinghouse Machine Works at East Pittsburgh in 1909, he was connected with the Chicago & Northwestern R.R. as general superintendent of its Chicago shops. When the Westinghouse company opened its new plant at Essington, Penn., Mr. Otto supervised the installation of the machinery, and in February, 1918, he was permanently transferred to the new works, where he remained until his death.

He is survived by his widow, a daughter and three brothers.

The United States must supply part of the coal shortage of 40,000,000 tons in Europe, according to report by George S. Rice, Chief Mining Engineer of the Bureau of Mines, Department of the Interior. With a reduction in England from an eight- to a seven-hour day on June 16, and with the prospect of a six-hour day by the end of 1920, there will be a decreased output of 70,000,000 tons, leaving a possible margin of only 7,000,000 tons for export, if restrictions put in force during the war are removed. If the restrictions are continued, there will still be 40,000,000 tons to be supplied from the outside. France, Italy, Spain, Norway and Sweden have been largely dependent on England for coal, while the French mines, which produce 20,000,000 tons annually, were destroyed by the Germans. Italy in 1913 imported 10,000,000 tons from England. Mr. Rice reports that American companies are preparing to care for European needs. The figures of the Bureau of Mines show an immediate capacity in this country of 750,000,000 tons as against the largest single year's production in 1918, of 600,000,000 tons.

Patent rights have been taken out in France by P. L. Weston (No. 487,380) to cover the use of thin steel or iron belts on magnetized pulleys to transmit power. The magnetization of the pulleys is effected by windings lying in helicoidal slots on the surface of the pulleys. The thickness of the belt should not exceed about 0.06 times the diameter of the smallest pulley. With a steel belt of ⅛-in. thickness making contact over an arc of 145 deg. on a pulley of 10-in. diameter running at 4000 revolutions per minute, it is possible to transmit more than 200 hp. per inch width of belt. With a pulley of 50-in. diameter running at 800 revolutions per minute a belt of 1-in. width will transmit 1000 hp. Steel belts may be run at speeds of 18,000 ft. per min. so that this method of transmission is suitable for speed reduction with turbines.—*The Engineer* (London).

Personals

C. O. Mailloux, consulting electrical engineer, has returned to New York from a six months' trip in Europe.

H. W. Rand, formerly connected with the Chapman Valve Co., is now with the Ashton Valve Co., of Cambridge, Mass.

William J. Neville has been appointed Southern district sales manager of the Ashton Valve Co., of Boston, Mass., with offices in the Candler Building, Atlanta, Ga.

F. E. Ransley, formerly with the Doerman-Roehrer Co., of Cincinnati, has recently joined the selling force of the Dominion Asbestos and Rubber Corporation.

J. R. Kommer, who has been associated with the Federal Engineering Co. for the last fifteen years, has resigned to engage in waterworks consulting engineering exclusively.

H. H. Esselstyn has resigned as Commissioner of Public Works of Detroit, and will devote his entire time to the interests of his firm, Esselstyn, Murphy & Hanford, engineers and architects.

C. F. Miller, who has had charge of the Los Angeles office of the Dearborn Chemical Co. for many years, has resigned and assumed the management of the Independent Speedometer Repair Co., of Los Angeles.

J. J. Brown, formerly vice-president and general manager, has been elected president of the Wheeler Condenser and Engineering Co., Cartaret, N. J.,, succeeding Charles W. Wheeler, recently deceased. H. S. Brown of Boston has been elected vice-president.

Alex. B. Burns has been appointed manager of the stationary department of the Dearborn Chemical Co. on the Pacific Coast, with headquarters in Los Angeles. Mr. Burns has been with the Dearborn Co. on the coast for several years in the position of supervising engineer.

Charles C. Trump, formerly with the Humphrey Gas Pump Co., and the Stumpf Una-Flow Engine Co., Inc., of Syracuse, N. Y., is now connected with the Fuller-Lehigh Co., Fullerton, Penn., and the Fuller Engineering Co., of Allentown, Penn., as sales engineer in the New York City office, at 50 Church St.

F. V. Larkin, assistant general superintendent of the Harrisburg Pipe and Pipe Bending Co., and formerly assistant professor of mechanical engineering at Lehigh University, will return to Lehigh as professor of mechanical engineering on Sept. 1, to fill the chair vacated by the death of the late Prof. J. F. Klein, head of that department for many years.

Col. C. H. Crawford, until recently assistant superintendent of the Eddystone plant of the Baldwin Locomotive Works at Philadelphia, has been transferred to South America as its Brazilian manager, with offices in Rio de Janiero. Colonel Crawford will also act as representative of the American Association of Engineers in South America. His address will be Caisa Postal 350, Rio de Janeiro, Brazil.

Prof. Charles E. Lucke, of the School of Mechanical Engineering, Columbia University, has been honored for war services with the rank of Commander in Naval Reserves. A naval regulation has been broken in bestowing this rank on a civilian, the highest heretofore being that of lieutenant-commander to men from civil life. Professor Lucke trained thousands who served on submarine chasers.

Miscellaneous News

The American Association of Engineers is to open an office in New York City in charge of K. B. Knudson. The temporary address of the chapter will be 50 Church St., N. Y. C.

The Wellsburg Light and Power Co., of Wellsburg, W. Va., was destroyed by fire caused by a bolt of lightning during an electrical storm on July 15. Nobody was injured. The property loss is estimated at $100,000.

Members of the Technical and Mercantile Commission, representing the Czecho-Slovak republic, were recently received in Washington by George Otis Smith, director of the Geological Survey. This commission is touring the United States, investigating water power, methods of flood control, hydraulic fill dams and methods of irrigation. They will visit some of the largest hydro-electric plants while here.

Business Items

The American Pattern Works Co., of York, Penn., has taken over the entire business formerly conducted by the American Pattern Works.

The Wagner Electric Manufacturing Co., of St. Louis, announces the removal of its Philadelphia office, service station and warehouse to 1632-34 Sansom Street.

The Chicago Pneumatic Tool Co. announces the removal of its Minneapolis office from the Metropolitan Bank Building to Fifth Ave. and Fifth St. South, where a complete stock of the company's products will be maintained.

The Gould Supply Co., Inc., has taken over the business of the Gould Co., of Portland, Ore. The directors of the new company are William P. F. Ayer, president; Thomas Nickerson, vice president; G. A. Ricker, treasurer; Theodore W. Little and Carl T. Keller, all of whom are prominently connected with the Walworth Manufacturing Co.

THE COAL MARKET

BOSTON—Current prices per gross ton f.o.b. New York loading ports:

Anthracite

	Company Coal
Egg	$7.80@7.95
Stove	7.95@8.15
Chestnut	8.05@8.35

Bituminous

	Clearfields	Cambrias and Somersets
F.o.b. mines, net tons	$2.35@2.80	$2.80@3.40
Philadelphia, gross tons	4.49@5.00	5.00@5.70
New York, gross tons	4.85@5.35	5.35@6.10
Alongside Boston (water coal), gross tons	6.35@7.05	6.85@7.50

Pocahontas and New River are quoted at $6.00@6.25 per gross ton f.o.b. Norfolk and Newport News, Va., in response to export demand. There are practically no spot sales for coastwise shipments.

NEW YORK—Current quotations, White Ash, per gross tons, f.o.b. Tidewater, at the lower ports* are as follows:

	Mine	Tidewater		Mine	Tidewater
Broken	$5 95	$7 80	Pea	5.10	6.85
Egg	6 15	8.00	Buckwheat		
Stove	6.40	8.25		3.40	5.15
Chestnut	6.50	8.35	Rice	2.75	4.50
			Barley	2.25	4.00

Bituminous

	Spot
South Fork (Best)	$2.95@3.25
Cambria (Best)	2.95@3.10
Cambria (Ordinary)	2.45@2.60
Clearfield (Best)	2.95@3.10
Clearfield (Ordinary)	2.45@2.60
Reynoldsville	2.50@2.75
Quemahoning	2.85@3.00
Somerset (Best)	2.85@3.00
Somerset (Poor)	2.35@2.60
Western Maryland	2.35@2.60
Fairmont	1.90@2.25
Latrobe	2.20@2.35
Greensburg	2.35@2.50
Westmoreland Z in	2.75@2.90
Westmoreland run-of-mine	2.50@2.60

Quotations at the upper ports for both bituminous and anthracite are 5c. higher on account of the difference in freight rates, and are exclusive of the 3% war freight tax.

PHILADELPHIA—The price per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide are as follows:

	Line	Tide		Anthracite Line	Anthracite Tide
Broken	$5.95	$7.80	Buckwheat	$3.40	$4.45
Egg	6.05	7.90	Rice	2.75	3.65
Stove	6.30	8.15	Boiler	2.50	3.50
Nut	6.40	8.25	Barley	2.25	3.15
Pea	5.00	6.60	Culm	1.25	2.15

CHICAGO—Current prices per ton for Illinois and Indiana coal are as follows:

Illinois

Williamson, Saline and Williamson Counties	Southern Illinois F.o.b. Mines	Northern Illinois F.o.b. Mines
Prepared sizes	$2.55@$2.75	$3.25
Mine-run	2.35@ 2.50	3.00
Screenings	1.85@ 2.20	2.75

BIRMINGHAM—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Prepared	Slack and Screenings
Big seam	$2.45	$2.75	$2.40
Black Creek and Cahaba	3.45	3.75	3.05
Jagger - Pratt Corona	2.85	3.05	2.45
Blacksmith	....	5.25	.....

Domestic quoations, slightly increased, are as follows:

	Lump and Nut
Black Creek and Cahaba	3.95@$4.60
Corona	3.50
Jagger	3.50
Montvallo	5.00

ST. LOUIS—The prevailing circular per net ton f.o.b. mines is as follows:

Franklin County	Mt. Olive and Staunton	Standard
Prepared sizes, lump, egg, Nos. 1 and 2 nut	$2.75	.....
Williamson County		
Prepared sizes, lump, egg, nut	$2.55	$2.55
Mine-run	2.35	2.20
Screenings	2.20	2.05
3-in. lump	....	2.30
2-in. lump	....	....

$2 00@2.25	
1.60@1.75	
1.15@1.30	
.....	
1.75@1.90	

Williamson-Franklin rate to St Louis is $1.07: other rates 92½c.

New Construction

PROPOSED WORK

Conn., Hartford—The Board of Contract & Supply will soon award the contract for supplying fire alarm cables, 750 ft. each of 15, 20, 30, 35, 40 and 50 lb. and 3000 ft. of 25 lb.

Conn., New Britain—The School Board will install a steam heating system in the 2 story, 80 x 272 ft. school which it plans to build on Bassett St. Total estimated cost, $200,000. C. C. Palmer, 272 Main St., Arch.

Conn., New Britain—The State Board of Education, Hartford, will receive bids until August 1, for the construction of a 2 story, 64 x 110 ft. school addition on Camp St. A steam heating system will be installed in same. Total estimated cost, $160,000. W. F. Brooks, Lewis and Gold St., Hartford, Arch.

Conn., New Britain—The State Board of Education will receive bids until August 1 for the construction of a 3 story, 80 x 113 ft. school. A modulation steam heating system will be installed. W. F. Brooks, Gold St., Hartford, Arch. Noted Feb. 4.

Conn., Putman—The Manhasset Manufacturing Co. will soon award the contract for the construction of a 2 story, 100 x 200 ft. mill. A steam heating system will be installed in same. Total estimated cost, $125,000.

Conn., Warehouse Point—The Hartford County Home is preparing plans for repairing and building an addition to the home to include a heating plant. Total estimated cost, $200,000. Max J. Unkerbach, 162 Main St., New Britain, Arch.

N. Y., Bronx—The Board of Education, 500 Park Ave., New York City, will install a steam heating system in the 5 story, 230 x 280 ft. school which it plans to build to P. S. No. 62 on Liggett, South Bone and Fox Sts., Bronx Boro. Total estimated cost, $600,000. C. B. J. Snyder, Municipal Bldg., New York City, Arch.

N. Y., Brooklyn—The I. Candy Manufacturing Co., Inc., c/o W. T. McCarthy, Arch., 16 Court St., will soon receive bids for the construction of a 3 story candy factory. A steam heating system will be installed. Total estimated cost, $200,000.

N. Y., Canandaigua—The city plans to build an ice making plant. Estimated cost, $60,000. Address Pres. of Bd. Pub. Wks.

N. Y., Jamaica—The Essemen Realty Corporation, Fulton St., will construct a 5 story hotel by day labor. A steam heating system will be installed in same. Total estimated cost, $300,000. H. T. Jeffrey, Jr., Fulton St., Engr.

N. Y., Johnson City—R. C. Pratt plans to build an artificial ice making plant here and install necessary equipment. Total estimated cost, $175,000.

N. Y., Oswego—The Kirk Maher Co., 59 West Main St., Malone, has purchased the O'Keefe Bldg., here, and plans to remodel and build an addition to same for its own use. Ice making and refrigeration equipment will be installed. Total estimated cost, $25,000-$30,000.

N. Y., Pelham—The Board of Education will soon award the contract for the construction of a 2 story, 168 x 171 ft. school. A steam heating system will be installed. Total estimated cost, $115,000. Tooker & Marsh, 101 Park Ave., New York City, Arch. Noted May 13.

N. Y., Penn Yan—Nestle's Food Co., 130 William St., New York City, will install boilers in the milk station on Jacob Street which it plans to rebuild. Total estimated cost, $45,000.

Penn., Philadelphia—The Union National Bank, 3rd and Arch St., will receive bids in August for the construction of a 3 story, 60 x 75 ft. bank. A steam heating system will be installed in same. Total estimated cost, $100,000. J. T. Brugger, 505 Chestnut St., Arch.

Ky., Ashland—The Field Furniture Co. will soon receive bids for the construction of a 6 story, 30 x 145 ft., brick and concrete retail store and office building on Main St. A steam heating system will be installed in same. Total estimated cost, $275,000. F. L. Packard, Hayden Bldg., Columbus, O.

Ohio, Cleveland—The Aetna Rubber Co., 815 East 79th St., will build a 1 story, 29 x 37 ft. boiler room. Estimated cost, $6000.

Ohio, Cleveland—The Durable Tire & Rubber Co., 1115 Citizens Bldg., will install a steam heating system in the 3 story, 50 x 200 ft. factory which it plans to build on East 49th St. and Newburgh & South Shore Ry. Total estimated cost, $500,000. Engineer not selected.

Ohio, Cleveland—The McElrath Tire & Rubber Co., 620 Union Bldg., will install a steam heating system in the 2 story, 60 x 200 ft. factory and power plant which it plans to build on East 131st St. Total estimated cost, $80,000. Architect not selected.

Ohio, Cleveland—The Pauled Realty Co., Hippodrome Bldg., will install a steam heating system in the 5 story, 75 x 240 ft. theatre which it plans to build on East 105th St. and Euclid Ave. Total estimated cost, $400,000. Address Mr. Berne. Engineer not selected.

Ohio, Cleveland—The C. H. Snearner Furniture Co., 72 Wymore Ave., will install a steam heating system in the 4 story, 270 x 780 ft. commercial building which it plans to construct at 10022 Euclid Ave. Total estimated cost, $150,000. Engineer not selected.

Mich., Detroit—F. C. Brandt, 884 Michigan Ave., will soon award the contract for the construction of a 1 story, 60 x 100 ft. garage. A steam boiler for heating purposes will be installed in same. Total estimated cost, $15,000.

Mich., Detroit—The Packard Motor Car Co., East Grand Blvd., will soon award the contract for the construction of a 3 story, 196 x 201 ft. service station and garage on Antoine and Woodbridge St. A vacuum steam heating system, vacuum pumps and two boilers will be installed in same. A. Kahn, Marquette Bldg., Arch.

Mich., Wyandotte—B. C. Wetzel & Co., Arch., 2317 Dime Bank Bldg., Detroit, is preparing plans for the construction of a 2 story, theatre and office building. A steam heating system will be installed in same. Total estimated cost, $180,000. Owner's name withheld.

Ill., Chicago—The Argonne Hotel Co., c/o R. C. Harris, Arch., 190 North State St., will install a steam heating system in the 10 story, 130 x 170 ft. hotel which it plans to build on Sheridan Road and Chase Ave. Total estimated cost, $900,000.

Wis., Kiel—The Kiel Woodenware Co. will soon award the contract for installing two 16 x 66 ft. high pressure boilers. Estimated cost, $15,000. Cahill & Douglas, 301 Grand Bldg., Milwaukee, Engr.

Wis., Sheboygan—The Ford Motor Co., Detroit, Mich., will install a steam heating system in the 5 story, 250 x 500 ft. factory which it plans to construct in Lake View Addition. Total estimated cost, $200,000. Architect not selected.

Minn., Chisholm—The Board of Education will install steam heating and mechanical ventilating systems in the 2 story, 100 x 120 ft. school which it plans to build. Total estimated cost, $200,000. W. T. Bray, Torrey Bldg., Duluth, Engr.

Minn., Gilbert—E. H. Berg, engr., Eveleth, will receive bids until August 1 for the construction of a 2 story, 100 x 110 ft. auditorium on Main St. for the city. A steam heating and mechanical ventilating system will be installed in same. Total estimated cost, $100,000.

Minn., Montevideo—B. O Bonn, city clk., will soon award the contract for extending the waterworks system. Equipment including a generator, 750 gal. per minute centrifugal pump with motor, switchboard, piping, etc., will be installed.

Minn., Nopeming—The St. Louis County Tuberculosis Commission will receive bids until August 18th for the construction of the three story, 40 x 320 ft. reinforced concrete building. A steam heating and mechanical ventilating system will be installed in same. Total estimated cost, $240,000. Halstead & Sullivan, Palladio Bldg., Duluth, Engr.

Minn., St. Paul—The Blue Mouse Theatre, 617 East 87th St., will soon award the contract for the construction of a 2 story, 50 x 150 ft. moving picture theatre on Hennepin Ave., between 7th and 8th St. A vapor heating system will be installed. Total estimated cost, $70,000. H. Lowrie, Paxton Blk., Omaha, Neb., Arch.

Minn., Virginia—The city will receive bids about September 1 for the construction of a 2 story, 190 x 275 ft., city hall and community building on 1st St., S. A steam heating and mechanical ventilating system will be installed. Total estimated cost, $282,000. A. W. Kerr & Co., Virginia, Engr.

Minn., Virginia—The Commissioners of St. Louis Co., Duluth, are having plans prepared by Croft Boerner, Arch., Palace Bldg., Minneapolis, for the construction of 2 story courthouse. A steam heating system will be installed in same. Total estimated cost, $250,000. Noted Apr. 29.

Kan., St. John—The city will receive bids until Aug. 6 for the installation of an electric light plant, and will install two 80 hp. boilers and 2 generators. Burns & McDonald, 400 Interstate Bldg., Kansas City, Mo., Engr. Noted May 20.

Neb., Omaha—The Sinclair Refining Co., 111 West Washington St., Chicago, Ill., plans to build a plant on 11th and Seward St., here, to include a boiler house. Total estimated cost, $250,000. W. T. Dinkins, 901-5 Woodmen of the World Bldg., Omaha, Local Mgr.

Mo., Kansas City—The House of the Good Shepherd plans to construct a power plant and install laundry equipment. Total estimated cost, $18,000.

Mo., Kansas City—Wolf Bros. Furnishing & Clothing Co. plans to install a refrigeration system. Estimated cost, $7000.

Mo., St. Joseph—The Roberts Cone Co., 709 North 3rd St., will install a steam heating system in the 5 story, 100 x 140 ft. factory which it plans to build. Total estimated cost, $200,000. Architect not selected.

Utah, Milville—The City will receive bids until August 4 for the construction of a complete electric distribution system for heat, light and power. Estimated cost, $30,000.

Cal., Los Angeles—Train & Williams, Arch., 225 Exchange Bldg., will soon receive bids for the construction of a 2 story, 92 x 100 ft. church on Olivera and Marchesault St., for the Methodist Episcopal Diocese, Wright & Callender Bldg. A hot air heating and ventilating system will be installed in same. Total estimated cost, $150,000.

Cal., Marysville—C. W. Burrell, Arch., First Trust Bldg., Oakland, will soon receive bids for the construction of a 4 story, 119 x 160 ft. reinforced concrete and brick hotel, on 5th and E St., for the Coyt Investment Co., 306 14th St. A steam heating system will be installed. Total estimated cost, $250,000.

Cal., Salinas—The Trustees of Salinas Union High School District have voted $250,000 bonds for the construction of a high school. A steam heating system will be installed. R. Kyckhoff, Watsonville, Arch.

Cal., San Francisco—The Pacific Orphan Asylum plans to construct an orphan asylum on Ocean Ave. A steam heating system will be installed in same. Total estimated cost, $500,000. A. H. Jacobs, 110 Sutter St., Arch.

Cal., San Francisco—St. Francis Hospital, Bush St., will soon receive bids for the construction of a new central heating plant for the 6 story hospital which it plans to build. Total estimated cost, $250,000. A. I. Coffey, Humboldt Bank Bldg., Arch.

CONTRACTS AWARDED

Mass., Worcester—James Smith & Co., 99 Hope Ave., has awarded the contract for a 2 story, 60 x 212 ft. brick machine shop on Southbridge St., to E. J. Cross Co., 82 Foster St. An electrical power plant will be included in the project.

N. Y., Brooklyn—The Board of Education, 500 Park Ave., New York City, has awarded the contract for the construction of an addition to the school on McDougal St. and Rockaway Ave., to P. Cleary, 115 Marion St. A steam heating system will be installed. Total estimated cost, $208,700.

N. Y., Greensburg—The Board of Education has awarded the contract for the construction of a 2 story school to Oscawana Bldg. Co., 101 Park Ave., New York City. A steam heating system will be installed in same. Total estimated cost, $90,000.

N. Y., Long Island City—The Globe Thread Co., Pierce Ave., has awarded the contract for the construction of a 50 x 141 ft. factory on Pierce and 7th Aves., to L. Barth & Sons, 32 Union Sq., New York City. A steam heating system will be installed. Total estimated cost, $100,000.

N. Y., New York—The Finkel Umbrella Frame Co., 2534 East 177th St., has awarded the contract for the construction of a 1 story, 100 x 200 ft. factory on Bush Ave. and 177th St., Bronx Boro., to I. Maifello, Williamsbridge. A steam heating system will be installed in same. Total estimated cost, $75,000.

N. Y., New York—The congregation of the Fifth Church of Christ Scientist, 42nd St., has awarded the contract for the construction of a 20 story, 145 x 179 x 200 ft. church on Madison Ave., between 43rd and 44th St., to W. J. Taylor, 7 East 42nd St. A steam heating system will be installed in same. Total estimated cost, $3,000,000.

N. Y., New York—The J. Eichler Brewing Co., 3582 3rd Ave., has awarded the contract for converting the 3 story, 64 x 84 ft. brewery at 169th St. and 3rd Ave. into an ice plant, to Hubener & Escher, 748 Melrose Ave. Estimated cost, $37,000.

N. Y., New York—The Philip Wurlitzer Co., 113 West 40th St., has awarded the contract for the construction of a 15 story, 50 x 85 ft. store and loft building at 119 West 41st St., to J. A. Zimmerman, 18 East 41st St. A steam heating system will be installed in same. Total estimated cost, $600,000. Mannicke & Franke, 25 East 26th St., Arch.

N. Y., New York—H. Phipps Estate, 737 5th Ave., has awarded the contract for the construction of a 14 story, 60 x 105 ft. office building on 46th St. and Madison Ave., to the Caldwell-Wingate Co., 281 4th Ave. A steam heating system will be installed in same. Total estimated cost, $500,000.

N. Y., Port Jervis—The Board of Education, 500 Park Ave., New York City, has awarded the contract for the construction of a 4 story school, to the Oscawana Bldg. Co., 101 Park Ave., New York City. A steam heating system will be installed in same. Total estimated cost, $85,000.

N. Y., Salamanca—The Board of School Commissioners have awarded the contract for installing a steam heating and ventilating system in the Maple St. School, to the Johnson Heating Co., New York City, at $16,000. Noted July 22.

N. J., Plainfield—The Board of Education has awarded the contract for the construction of a 2½ story, 55 x 150 ft. school on Emerson Ave., to Bandandt & Boerinder, Plainfield. A steam heating system will be installed in same. Total estimated cost, $140,000. Noted July 1.

Ohio, Cleveland—The Sixth City Realty Co., Guardian Bldg., has awarded the contract for the construction of a 4 story, 167 x 370 ft. garage on East 6th and St. Clair Ave., to C. A. Garson, 6804 Euclid Ave. A steam heating system will be installed in same. Total estimated cost, $1,300,000.

Ohio, Cleveland—The Union Garage Co., 517 Sloan Bldg., has awarded the contract for the construction of a 2 story, 165 x 212 ft. garage on West St. Clair Ave., to C. A. Carson Co., 6408 Euclid Ave. A steam heating system will be installed in same. Total estimated cost, $400,000.

Mich., Ferndale—G. J. Hass, Arch., 1514 Kresge Bldg., Detroit, has awarded the contract for the construction of a 2 story, 138 x 143 ft. school on Woodward Ave., to W. H. Mueller, 1711 Ford Bldg., Detroit. Hot blast heating apparatus will be installed in same. Total estimated cost, $100,000.

Mich., Port Huron—The First National Exchange Bank has awarded the contract for the construction of a 2 story bank on Huron Ave. and Quay St., to Hoggson Bros., 485 5th Ave., New York City. A steam heating system will be installed in same. Total estimated cost, $125,000.

Ill., Chicago—Straus & Schraus have awarded the contract for the construction of a 2 story, 65 x 120 ft. warehouse, at 105 West 35th St., to E. W. Sproul Co., 2001 West 35th St. A steam heating system will be installed. Total estimated cost, $120,000.

Wis., Port Washington—The city has awarded the contract for installing a generator and switchboard in the power house, to the General Electric Co., Milwaukee. Estimated cost, $30,000.

Kan., Topeka—The Masonic Bodies, 320 West 8th St., have awarded the contract for the construction of a 3 story, 140 x 265 ft. temple, to F. M. Spencer & Son, 215 Mulvane Bldg. A steam heating system will be installed in same. Total estimated cost, $500,000.

Ariz., Phoenix—The Arizona Packing Co. has awarded the contract for the construction of a 4 story, 200 x 250 ft. reinforced concrete building and a number of smaller buildings, using 2200 hp. and electric power, on Temple Rd., to the Packers' Architectural Engineering Co., Chicago. Estimated cost, $500,000.

Ont., Owen Sound—The town has awarded the contract for the construction of a hydro-electric power house, dam, etc., to W. M. Fletcher & Co., 151 Bloor St., W., Toronto. Estimated cost, $64,700.

Ont., Owen Sound—The City has awarded the contract for the construction of a hydro-electric plant, to the Canadian Westinghouse Co., Ltd., Hamilton. Electrical equipment, generators, transformers, etc., wil be installed in same. Total estimated cost, $90,000.

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